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Every Man an Efficiency Engineer

John Leitch in his excellent book, "Man-to-Man, the Story of Industrial Democracy," relates that in one plant at a meeting of the employees the suggestion was made by one that an efficiency engineer be called in to instruct the men in better methods for doing their work, and to increase production. Much discussion followed, and finally one of the men blurted out, "We have 268 efficiency engineers right here now!" (There were 268 employees in the plant, and they were all present at the meeting.)

There is a tremendous amount of sound reasoning and good judgment expressed in that short statement, and it should be true of every plant. When by instruction and coöperation each man is induced to take the interest that he should in the plant in which he is employed, then each man will become an efficiency engineer. It will be unnecessary to call in outside aid to find the weak spots, and to devise better methods of doing things. No man can be as familiar with the workings within a shop as he who spends day after day at his bench, at his lathe, or on whatever his job may be.

Every workman should constantly keep before his mind these three questions:

Am I doing my work in the most economical way for the interests of my employer? (Which, by the way, generally prove to be the employee's interests also.)

Am I eliminating all possible wastes of time, energy and material?

Am I doing everything possible to advance myself in my work, both to my own profit and for the interests of my employer?

If a man can answer "yes" to all these questions, then however humble may be his position, however rough and unskilled may be his labor, that man is an "efficient engineer," and as such is a most valuable asset to his employer. On the other hand, the reverse is true. Any man, no matter how high a position he may hold, who can not answer "yes" to the foregoing questions not only is depriving his employer of services that are his due, but is decreasing production, increasing costs and—what should be of more interest to him—retarding his own development and advancement. And it is such men that make it necessary to bring in efficiency experts from the outside.

The profession of efficiency engineering has been greatly abused, until in many plants an efficiency engineer is looked upon with suspicion by employer and employee alike. The mere use of the words arouses a feeling of hostility at once. This works a hardship upon the great number of men who are qualified by training and ability to give expert advice in matters of cutting costs, increasing production and reducing wastes, and who have made this work their profession.

But if the employees of every plant, large or small, would adopt for their motto the words, "Every Man an Efficiency Engineer," there would be no occasion for outside experts to be called in. Labor and Capital would alike benefit thereby, fuel administrators would be unnecessary, and power plants would operate at efficiencies heretofore unheard of.

EXTENSION *to* L STREET STATION, BOSTON

By CHARLES H. BROMLEY

The station represents the latest practice in large power-plant design. The boiler room is unequaled in provisions for convenient, economical performance. One 30,000-kw. single-cylinder impulse turbine is installed. A second 30,000 will be ready soon. Barometric condenser is used as heater. Main steam valves are remote-controlled electrically.

THE latest practice in power-station design is the new extension to the L Street Station of the Edison Electric Illuminating Co. of Boston, Mass. When more power was demanded of this station, the engineers had the advantage of making an extension along the most modern lines in building and equipment, instead of remodeling an old station, which in recent years has been the usual way of increasing a station's capacity. The headpiece is from the most recent photograph of the exterior of this station, and Fig. 13 shows a sectional view of the buildings and equipment of the recent extension. The station is exceptionally roomy, well-lighted and ventilated, and excellently equipped.

In the extension there are four Babcock & Wilcox cross-drum water-tube boilers (Fig. 2), each of 12,320 sq.ft. of heating surface. The turbine room now has one 30,000-kw. single-cylinder impulse turbine embodying the recent improvements made on this design by the General Electric Co. and another will soon be ready. The boiler room without question has no equal in point of design and equipment. Every provision that obviates or lightens heavy labor, that makes for convenience of operation and repair, that conduces to efficiency and checks and records it, is made. See Figs. 1 to 5, also Fig. 11. Each boiler is inclosed in a steel casing, its walls insulated; each has a Westinghouse 13-retort underfeed stoker with a clinker grinder. The retorts are sectionalized in three units of three retorts each and one unit of four retorts. The drive is by dustproof motor. Each stoker has four motors, one for each section of retorts. The forced-draft fans are on the boiler-room floor, and so, too, are the motor-driven centrifugal boiler-feed pumps.

With the type of settings under these cross-drum boilers the front of the boiler becomes the back as far as observation and control of fire goes. One man attends to the feeding of coal to all stoker hoppers and retorts by the use of 10-ton weighing lorry. Between the stoker side of the boilers and the back or control side there is a partition that keeps out the dust. The firemen are on the control side. The rheostats for the various motor controls are in the basement, chains connecting them with the control-room floor level at the boilers.

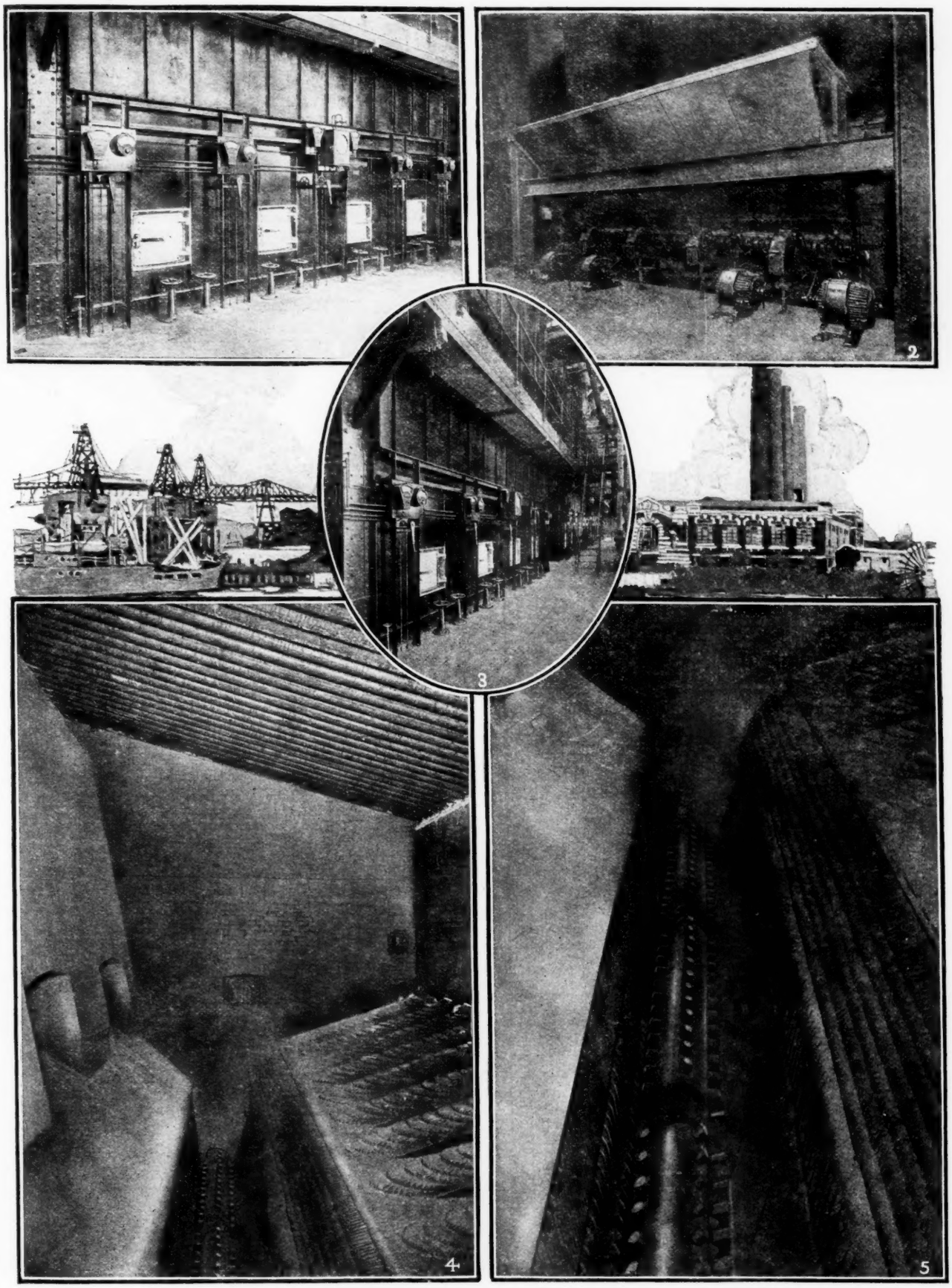
Each stoker has 13 retorts, the drive of which is sectionalized by four gear boxes with an individual motor for each section. This, of course, gives the crew positive mechanical control of the whole or any part of the fuel bed. The furnace has a combustion volume of 3000 cu.ft. and 930 lb. of coal per hour per retort. The ashpit volume is 1050 cubic feet.

The clinker grinder is of considerable interest, but as it was described in *Power* for Apr. 22, 1919, details here are unnecessary. Its performance is remarkable. New River coal, which averages 6.5 per cent. ash by analysis, which fuses at about 2500 to 2800 deg. F., is burned in this station. Analyses of the refuse passed through the grinder show it to contain from 6 to 7 per cent. carbon for the average over the usual operating day. The refuse may be emptied from the ash hoppers directly into motor trucks.

Each boiler has 50,000 cu.ft. per min. capacity at 7-in. static pressure in forced-draft fans, motor-driven, and 80,000 cu.ft. per min. in induced-draft fans, also motor-driven. The forced-draft fans are of straight-blade double-inlet type. The induced fans are of the multivane type.

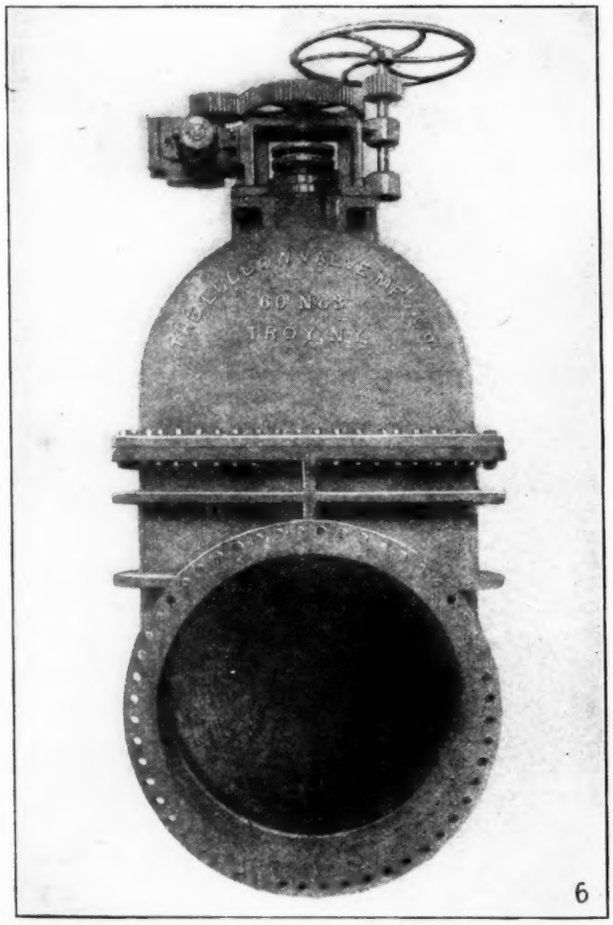
Each boiler has an economizer of 7728 sq.ft. heating surface, built for 300 lb. pressure.

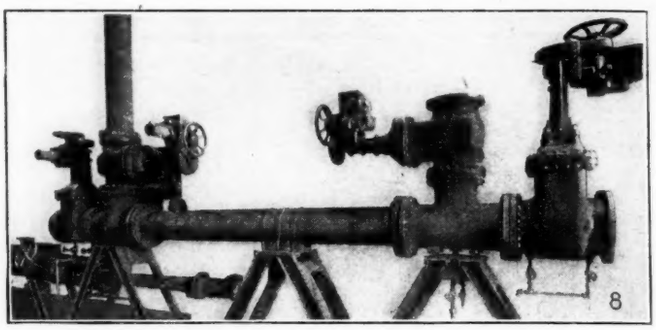
One of the features which impresses the visitor to the station is the adequate room, excellent ventilation and lighting everywhere provided. "It's a fine place to work in," is what one exclaims on seeing it. Unusual,

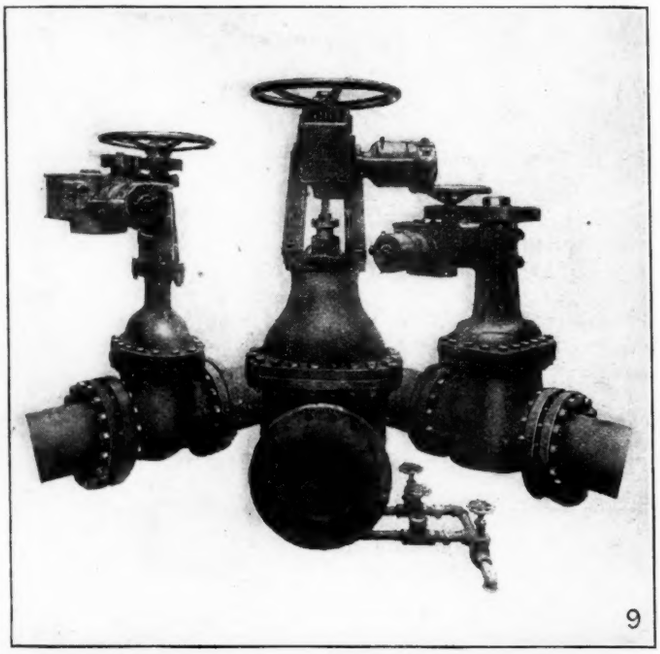


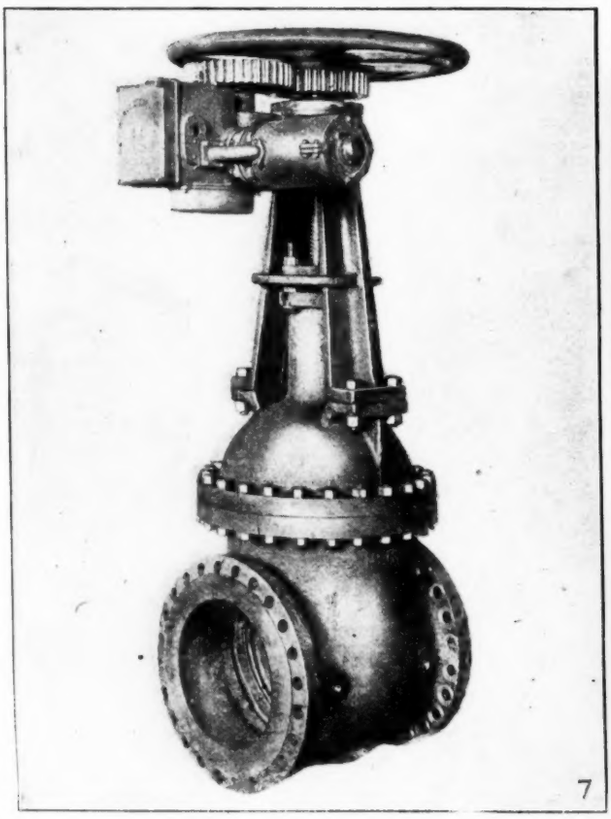
FIGS. 1 TO 5. BOILER-ROOM VIEWS IN THE L STREET STATION EXTENSION

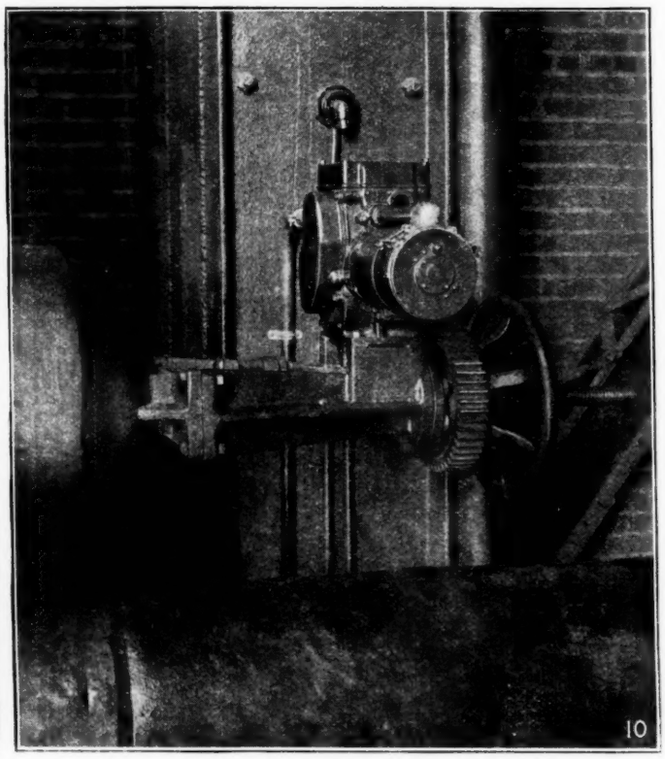
Fig. 1—The control side of one of the boilers. Fig. 2—Showing the stoker drive side. Fig. 3—Looking down the new boiler room, control side. Fig. 4—Combustion chamber of one of the boilers. Fig. 5—Looking down upon the clinker grinder.











FIGS. 6 TO 10. DEAN ELECTRICALLY CONTROLLED VALVES IN L STREET STATION

Fig. 6—A large gate valve. Fig. 7—One of the high-pressure steam valves. **Fig. 8**—The high-pressure steam header. **Fig. 9**—A connection to the header, showing three controlled valves. **Fig. 10**—A "close up" of one of the large valves in the steam line.

indeed, are the number of iron grating platforms and runways about the boiler room. There are few flanges or fittings that a man cannot work upon while standing on these gratings. One with station experience does not question this investment.

Automatic feed-water regulators are used, as is now general practice in all modern power plants.

The boiler room of the extension is tied into the steam distribution system of the older boiler room. The pressure on the lines of the new extension is 300 lb., that in the older plant 200 lb. Fig. 12 shows the tie-in connections. Note that the General Electric pressure-reducing valve is the connecting point between the 300-lb. and 200-lb. systems. To avoid the possibility of 300 lb. on the 200-lb. system, a bank of twelve 4.5-in. pop safety valves are provided. These relieve into a 20-in. spiral-riveted pipe which connects with the main atmospheric relief pipe. This application of this pressure-reducing valve is unique. The valve is made for, and for a number of years has been used on, Curtis mixed-pressure turbines, but its use as at this station is new. The advantages of remote control of valves, steam and water, is now so generally recognized that it is being applied in all modern power stations. The remote control of valves at L Street Station is a feature. See Figs. 6 to 10. The following description and explanation of valve control at this station was written for this article by P. P. Dean, the engineer who has developed this system of control:

A noteworthy feature of this installation is the piping and valve equipment, which is especially designed for the high pressure and superheat used. The majority of the valves are of Schütte & Koerting manufacture and are built with cast-steel bodies and fitted with monel-metal seat rings. The stem is also of monel, and this metal is used on account of its ability to stand excessive heat and also on account of its low coefficient of expansion. The valves are of the double-disk taper type, having a toggle form of wedge mechanism for keeping the disks tight against the seats. The thickness of metal in the valve body is greater than the manufacturer's standard, and the flanges also are of extra thickness. A number of the valves, however, on the same line, are built by the Nelson Valve Co.

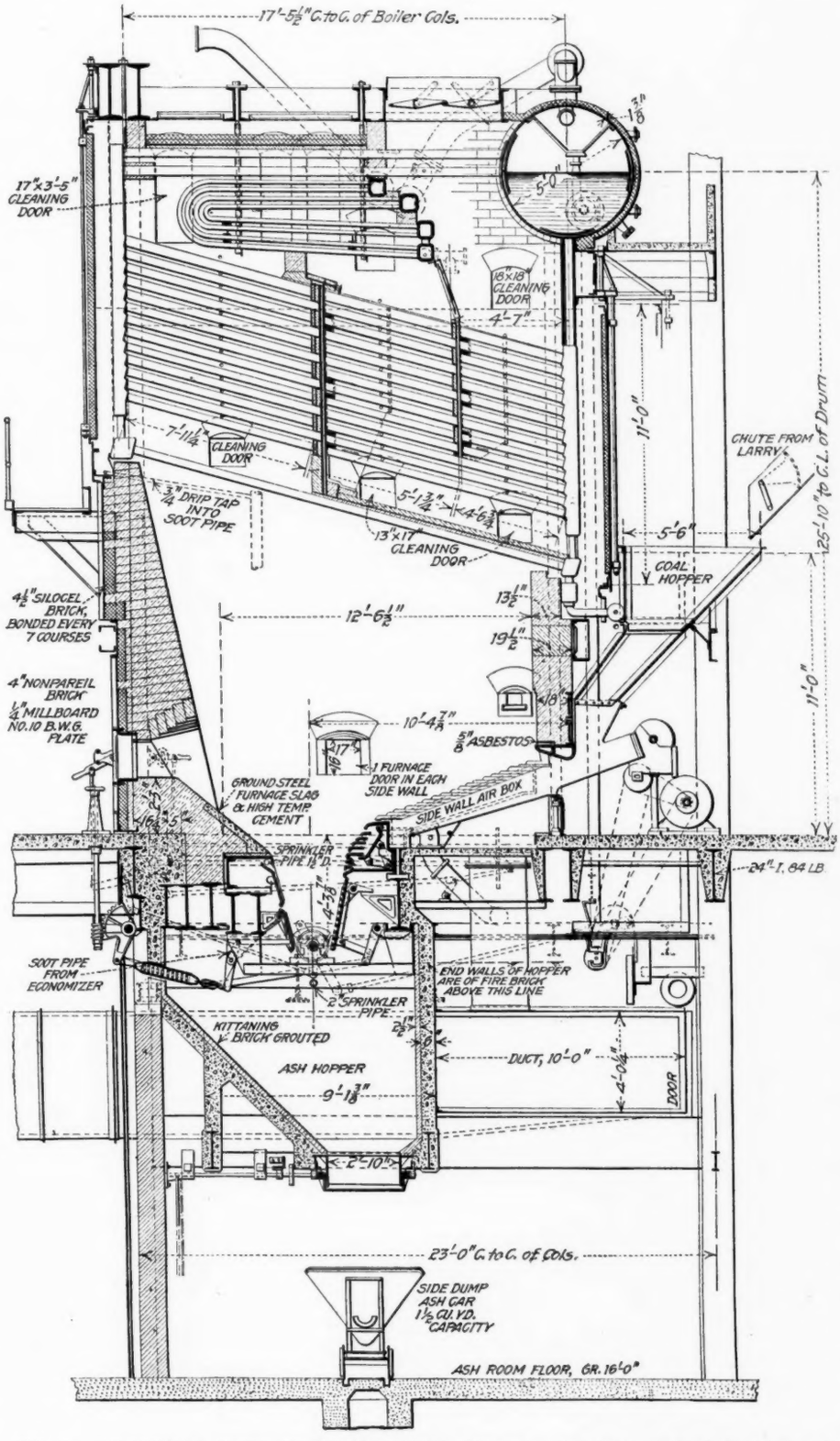


FIG 11. SECTIONAL VIEW OF CROSS-DRUM BOILER, CLINKER GRINDER AND ASH HOPPER

Eighteen of the important header and sectionalizing valves are equipped with electrical control containing a number of noteworthy features. This control is built by the Cutler-Hammer Manufacturing Co. and is known as the Dean control system. It is, so far as known, the only electrically operated valve-closing device that is built especially for valve operation. The operation is by electric motor geared to a system of reduction gearing to reduce the speed of the valve stem to 12 in. per min. The motor is of the series-wound multi-polar, high-torque type, totally inclosed and weatherproof, and is connected to a system of combined planetary and worm gearing for the necessary reduction. The gear is continually immersed in oil and is fitted into an oil-tight cast-iron case forming the main housing of the unit. Contained within the unit is a limiting device which stops the valve the moment the predetermined limits have been reached and eliminates drift or overtravel, which is usually the cause of so much jamming and consequent breaking of stems in valves of this description.

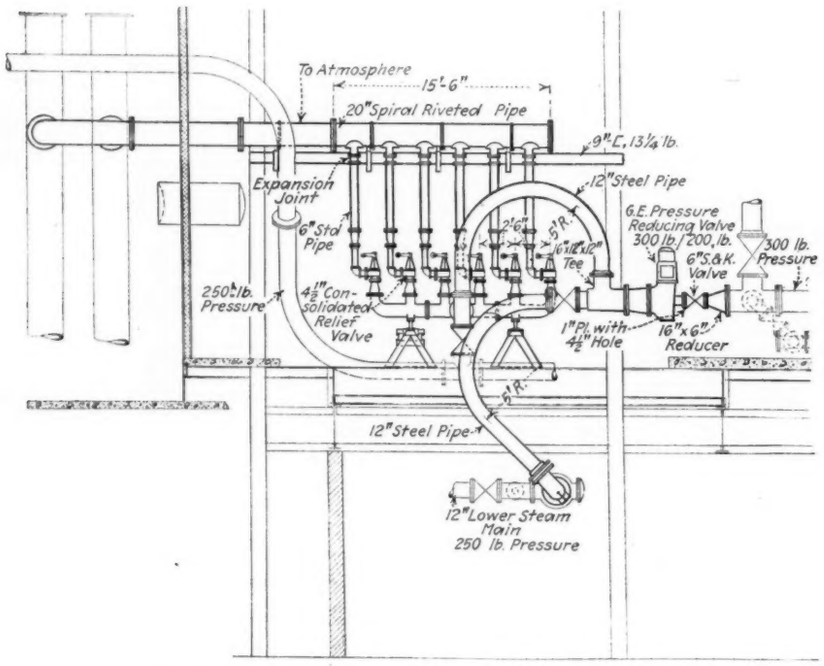


FIG. 12. ELEVATION OF NEW STEAM HEADER

A mechanical clutch automatically releases the high-speed motor and gears from the valve stem, and at the same moment an electrical limit opens the motor circuit.

The whole of the limit mechanism, gearing, etc., is totally inclosed, oil-tight and moisture-proof, while the cables from the motor to the switch housing are contained in cast-iron housing, making the unit waterproof and steamproof. The construction of the unit is such that the motor is a considerable distance from the valve yoke and free from the excessive heat consequent to the pressure and superheat used.

The Dean unit is fastened to a specially constructed valve yoke by four large studs, and the slow-speed shaft is geared to a valve stem by cast-steel cut gears which are completely inclosed by a sheet-iron casing. Handwheels are provided and keyed to an extended shaft so that manual operation may be performed in the event of failure of current. Some of the valves are controlled from one station and others from two remote points by the aid of standard Dean control stations which are fitted with red and green indicating lights. The electrical limit switch on the Dean unit is constructed to break the main circuit, which system, with

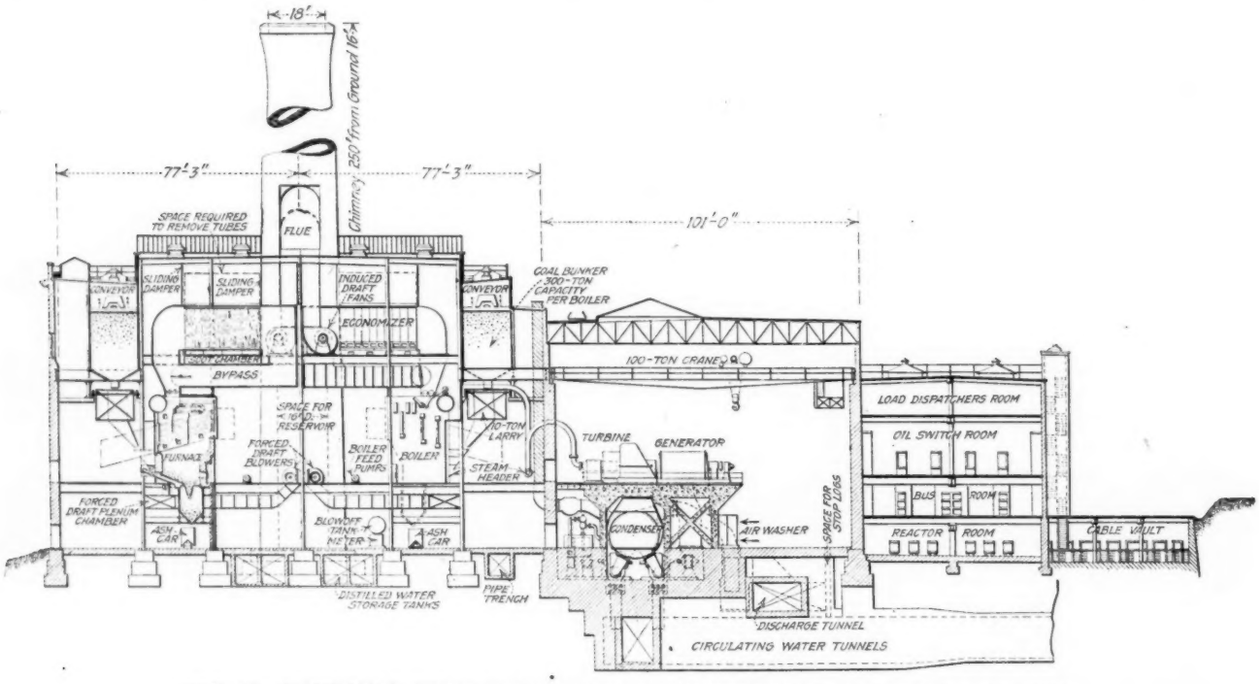


FIG. 13. SECTIONAL ELEVATION OF RECENT EXTENSION TO L STREET STATION

single-point control, obviates the necessity of any relay panel and makes the complete control possible by the aid of five wires between the Dean unit and the control station.

The indicating lights on the control station show the full-open and full-closed position of the valve, and the connections are such that should a fuse blow or an electrical connection become loose, the light will disappear and immediately indicate trouble. Either the red or green light always glows according to the position of

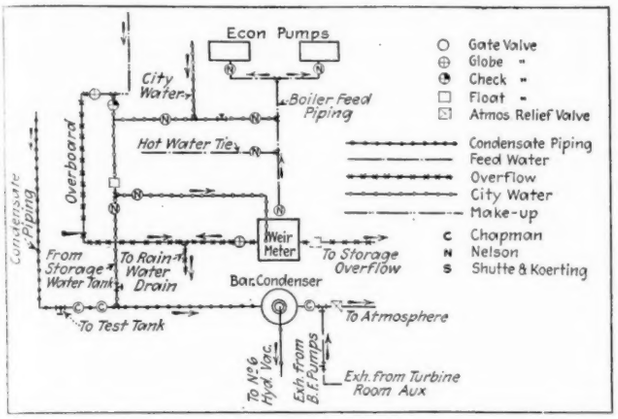


FIG. 14. DIAGRAM OF FEED-WATER PIPING

the valve, and forms a pilot showing the condition of the wiring, driving unit and all electrical connections.

The source of electric supply for the operation of all the valves is from a motor-generator set used for this purpose only, which is kept running continuously and has sufficient capacity to operate a majority of the valves at one time.

The wiring between the valves and source of supply is through steel conduit with water-type joints, as is the whole system and is, therefore, not affected by escaping steam or moisture.

An unusual feature of the station is the use of a barometer condenser as a heater for feed water. See the diagram, Fig. 14. The exhaust from the auxiliaries comes to this condenser, the condensing or injection water supply coming from the hotwell pumps. A 6-in. air connection from the top of the condenser connects with a hydraulic vacuum pump similar to those for the surface condensers for the main units; that is, the 30,000-kw. turbines. The tailpipe drops into a Bailey weir meter from which the water entering it through the tailpipe is picked up by the economizer pumps. Makeup water connections from a storage tank and from the city mains are of course provided.

The condenser-heater is located close to the 36-in. free exhaust pipe of the main turbines, a 24-in. free exhaust valve capable of being opened or closed from the operating floor being between the latter and the 30-in. auxiliary exhaust pipe.

The turbine room, in keeping with construction of the Edison Electric Illuminating Co., is roomy and beautiful. There will be three 30,000-kw. single-cylinder impulse machines. The generators are provided with water connections and nozzles which may be used to put out a fire should the generator get afire.

Boston has reason to be proud of this station. The writer is appreciative of the excellent coöperation given in the preparation of this article by Charles L. Edgar, president; I. E. Moultrop, superintendent of construction, and George E. Seabury, superintendent, station-engineering department, Edison Electric Illuminating Co., Boston

Calculations from a Flue-Gas Analysis of Loss Due to Incomplete Combustion

By H. M. Brayton, M.E.

Loss due to incomplete combustion which results in low boiler efficiency is a problem that has confronted combustion engineers for many years. It is still a vital problem, and many mechanical and chemical means have been employed in the effort to detect and remedy this loss.

The average engineer in the up-to-date power plant is accustomed to gage the efficiency of his boilers by the percentage of CO_2 which his recording apparatus shows. This record, however, is really not complete, and with this information alone it would be impossible to calculate the loss due to incomplete combustion no matter how much mathematics might be used. An analysis from an Orsat apparatus which shows the percentage of CO_2 is also necessary.

The object of this article is to show the practical man in as simple a way as possible just how to calculate this loss in his boilers and then to go a step farther and present a chart from which he can instantly read off the loss when once he knows the CO_2 and CO content of the flue gases. The analysis of flue gas is always stated in percentage of volume.

In order to fully explain each step as we proceed, it will be necessary to give some theory, but we shall make this theory as simple as possible. If the practical man

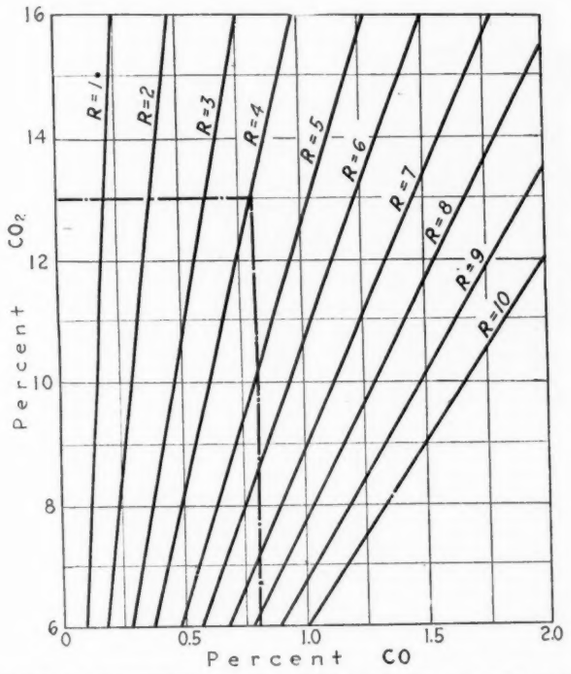


CHART TO DETERMINE PER CENT. OF HEAT LOSS FROM FLUE-GAS ANALYSIS

meets some new things, he must not think he cannot understand any of it, because we all have to meet and master new things every day. The vapor density of a gaseous compound is its weight referred to the weight of hydrogen as unity and is equal to one-half of its molecular weight. We all know that carbon dioxide (CO_2), as the formula indicates, is made up of one part of carbon which has an atomic weight of 12 and two parts of oxygen which has an atomic weight of 16. The molecular weight of a compound such as our CO_2 really represents is found by adding together all the atomic

weights. In this case the molecular weight of CO_2 becomes $12 + 16 + 16 = 44$. It was stated above that the vapor density was just one-half the molecular weight, so that the vapor density of CO_2 would be 22.

Now let us turn our attention to the other compound with which we are to deal; namely, carbon monoxide (CO). The molecular weight of this substance is $12 + 16 = 28$, and from this we determine that the vapor density is 14.

Our flue-gas analysis tells us just what part of the gas is composed of CO_2 and just what part is composed of CO. Let us assume that out of 100 cu.ft. of the flue gas the analysis shows P per cent. of it to be CO_2 and P' per cent. of it to be CO. The remainder consists, of course, of air and other gases. Nitrogen comprises the major portion of what is left, but we are not now interested in that phase of the problem. The question is, How much do the CO_2 and the CO in our 100 cu.ft. of gas weigh when *compared to hydrogen as unity?* We may write

$$22 \times P = W \text{ Weight of } CO_2 \quad (1)$$

$$14 \times P' = W' \text{ Weight of } CO \quad (2)$$

From the atomic weights as stated we know that in each pound of CO_2 gas there is $\frac{12}{44}$ or $\frac{3}{11}$ of a pound of carbon. In each pound of CO there is $\frac{12}{28}$ or $\frac{3}{7}$ of a pound of carbon. So that in the W parts by weight of CO_2 as shown, we have $\frac{3}{11}$ W parts of carbon and of the W' parts by weight of CO we have $\frac{3}{7}$ W' parts of carbon. Then

$$\frac{3}{11} W + \frac{3}{7} W' = W'' \quad (3)$$

where W'' is the total weight of carbon in the 100 cu.ft. of flue gas.

The foregoing discussion leads up to the actual determination of the loss due to incomplete combustion of the carbon in the coal. If the practical man has been thinking that the percentage of CO_2 in his flue gases was the whole story, he must change his habits of thought. A very small amount of the CO gas will cause a very serious loss.

If we will substitute the values of W and W' as found in equations (1) and (2) into equation (3), we shall have an expression showing the total weight of carbon in 100 cu.ft. of flue gas in terms of the percentage of CO_2 and CO. This expression reads as follows:

$$\frac{3 \times 22 \times P}{11} + \frac{3 \times 14 \times P'}{7} = 6P + 6P' = W'' \quad (4)$$

Then 6 P parts of carbon were burned to CO_2 and 6 P' parts of carbon were burned to CO.

Heat of combustion is that amount of heat which will be given off when a fuel burns or unites with oxygen. When carbon burns to CO_2 in the furnace, it gives off exactly 14,650 B.t.u. per lb. When carbon burns to CO in the furnace, it gives off only 4,400 B.t.u. per lb. The enormous loss in the latter case is evident.

Now 6 P parts of carbon burns to CO_2, hence the amount of heat generated by this carbon will be $6 \times 14{,}650 \times P$. (B. t. u.) and as $6P'$ parts of carbon burns to CO_2 the amount of heat generated by this carbon will be $6 \times 4{,}400 \times P'$(B.t.u.).

If all the carbon had burned to CO_2 the amount of heat generated would be $6\ (P + P')\ 14{,}650$ (B.t.u.). From the foregoing equations we may obtain at once the amount of heat generated by the carbon which is burned to CO_2 and that generated by the carbon which is burned to CO. All we need to know is the values of P and P', which are given by the Orsat apparatus.

The percentage of loss due to incomplete combustion is given, of course, by the ratio between the actual amount of heat generated and the heat which could have been generated had all the carbon united with the oxygen of the air and formed CO_2. This ratio actually gives the efficiency, and to get the loss we must subtract from 100. The efficiency of the furnace may be written in general terms as follows:

$$\frac{100 \times 6\ (14{,}650\ P + 4400\ P')}{6\ (P + P')\ 14{,}650} = \textit{per cent. efficiency} \quad (5)$$

or *per cent. efficiency* + *per cent. loss* = 100

or 100 — *per cent. efficiency* = *per cent. loss* (6)

If now we expand equation (5) and boil it down, we secure the following workable equation which gives us the percentage of loss.

$$\frac{70\ P'}{(P + P')} = \textit{Per cent. loss due to incomplete combustion} \quad (7)$$

Equation (7) is of great value to the power-plant engineer. With it he can quickly determine how the efficiency of his plant is running.

For the engineer who may have occasion to solve equation (7) many times each day, it may be interesting and valuable to know how to make this formula into a chart from which the value of the percentage of loss may be instantly determined without calculation. Let R equal the percentage of loss. Equation (7) may then be written thus:

$$70 \times P' - P' \times R = P \times R$$

$$P' \times (70 - R) = P \times R \quad (8)$$

which is an equation of the first degree in three variables. We may therefore proceed to plot P against P' for different values of R. When plotted, we shall simply have a series of straight lines each marked with the respective value of R which was used in determining it.

The accompanying chart illustrates the foregoing statements. The percentages of CO_2 (P) are plotted as ordinates on the vertical scale and the percentages of CO (P') as abscissas on the horizontal scale. Each straight line is marked with its respective value of the per cent. loss R.

To locate these lines substitute some value of R in equation (8). For example when $R = 2$ equation (8) becomes

$$P' \times (70 - 2) = 2 \times P$$

therefore

$$P' = \frac{2}{68} P = 0.0294\ P$$

Now if $P = 6$, $P' = 0.0294 \times 6 = 0.176$; and if $P = 16$, $P' = 0.0294 \times 16 = 0.470$.

This will locate two points on the line $R = 2$ and the line may now be drawn. The other R lines are located in the same way.

The use of the chart is simply a matter of finding the percentage of CO_2 on the vertical scale, the percentage of CO on the horizontal scale, following each as indicated by the dot-dash line on the chart until they meet, and the R line nearest this point of intersection is the percentage of loss due to incomplete combustion with this analysis. The illustration on the chart was taken with the $CO_2 = 13$ per cent. and the percentage of CO at 0.8. These lines extended meet almost exactly on the $R = 4$ line. This is merely a coincidence. Note that if we have an analysis of $CO_2 = 14$ per cent. and CO = 1 per cent., the lines meet between $R = 4$ and $R = 5$ and it would be close enough to call it a loss of 4.5 per cent.

This chart will be found useful in the boiler room and also in the laboratory where analysis of the flue gases is studied. The modern demand for efficiency makes it imperative that every man in the organization shall know how to calculate loss due to incomplete combustion.

Overload Relays—Principles of Operation

By VICTOR H. TODD

The principles of operation of different types of simple overload relays are discussed, and then consideration is given to such characteristics as inverse-time-limit, definite-time-limit to control the time of operation of relays, and the use of relay switches to relieve the relay contacts of handling heavy currents.

THE rapid strides taken toward the perfection of apparatus for the generation, transmission and utilization of electric energy have been closely followed by improved instruments to protect the apparatus and preserve continuity of service under all conditions. Like a silent sentinel, the protective relay stands on guard on the lines, day and night, ready to detect trouble instantly and disconnect faulty apparatus or sectionalize defective lines with almost human intelligence and with more than human accuracy.

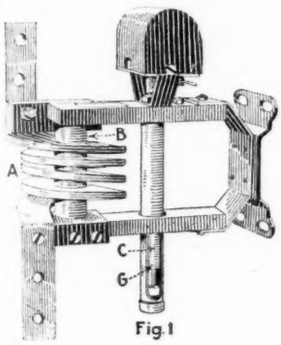


Fig. 1

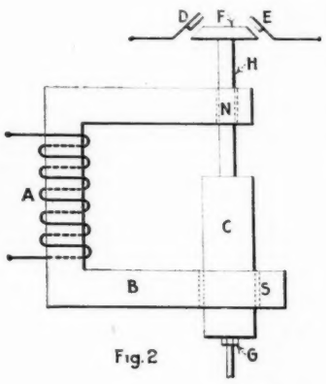


Fig. 2

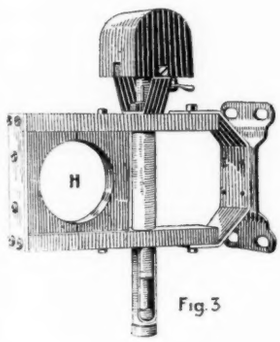


Fig. 3

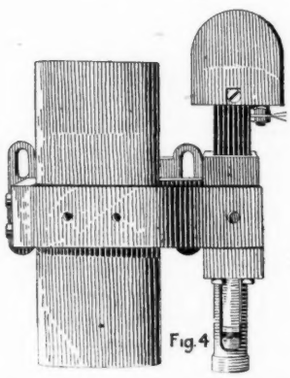


Fig. 4

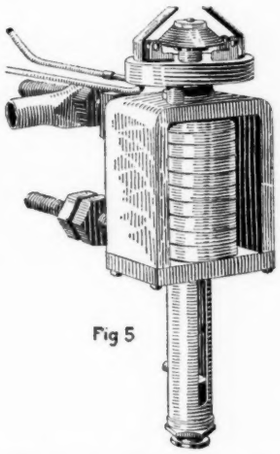


Fig. 5

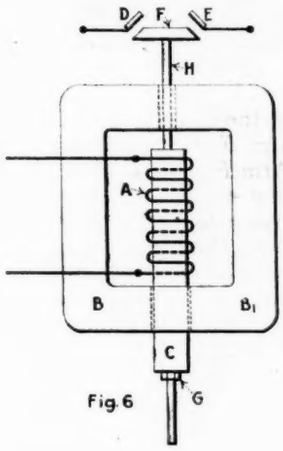


Fig. 6

FIGS. 1 TO 6. TYPES OF INSTANTANEOUS OVERLOAD RELAYS

Protective relays are very sensitive but ruggedly constructed electrical instruments interposed between the lines and the operating mechanism of a circuit-breaker in such a way that any disturbance on the line or in the apparatus does not act directly on the breaker, but operates the relay, and the relay, in turn, causes the circuit-breaker to open.

The function of the simple overload relay is to trip the circuit-breaker when the current exceeds a definite value. Incidentally, it may be stated that the term "overload" is used synonymously with "excess current." This latter term is the correct one, but general practice has been to use the term "overload" or "overload relay," when in reality what is meant is "excess current" or "excess-current relay." When a relay operates on actual load—that is watts—it is called a "watt relay" or "power relay."

A relay operating on the effect of a solenoid to raise an iron plunger, thus closing or opening contacts, is shown in Fig. 1. Referring to the diagram of parts shown in Fig. 2, winding *A* is wound around the iron core *B*. Supported at the two poles *N* and *S* is an iron plunger *C* arranged so that it may slide up and down. When the current in *A* reaches a certain value, the iron core *C* is lifted, thus closing the contacts *D* and *E* with bridge *F*, which will immediately trip the breaker, as previously described.

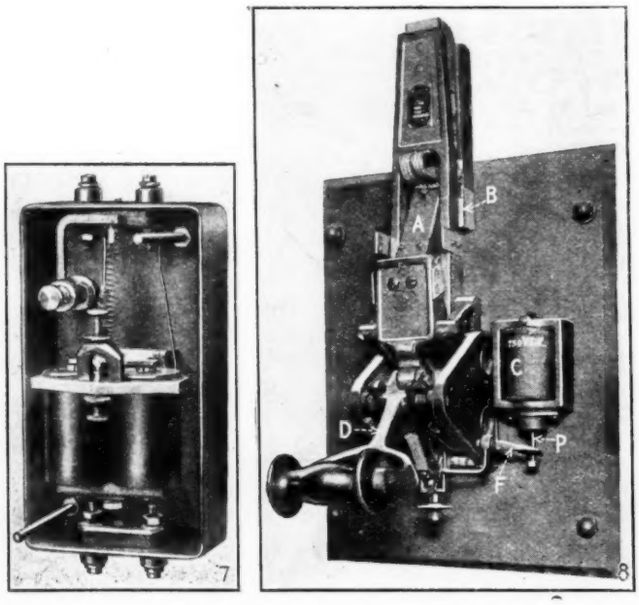
When the current is greater than 1000 amperes, a winding is not necessary, as the magnetism from the straight bar or cable produces sufficient flux to operate the relay. The relay may then take the form shown in Fig. 3, the cable simply passing through the large hole *H*, which is surrounded by insulating material. In Fig. 4 is another modification which may be used on a busbar that runs vertically instead of horizontally. In this case the magnetic circuit is simply clamped around the busbar, which is of course insulated.

In order to adjust these relays to operate on various loads, the plunger *C*, Fig. 2, is arranged with a nut *G* by means of which the plunger may be raised or lowered on the stem *H*. Thus if the plunger is at the lowest point, it will take a maximum of current to raise it, but if it is set high, then it will rise on a minimum of current.

Another form of overload (excess-current) relay, utilizing the same principle of operation as those already described, is shown in Fig. 5, and the arrangement of parts in Fig. 6. Coil *A* is wound on the central part over the iron plunger *C*, and the magnetic circuit is completed by the two parts *B* and B_1. The action is identical with the previously described relay; namely, when the current reaches a certain value, the plunger *C* is lifted upward, thus causing the contact disk *F* to short-circuit the two contacts *D* and *E*, which complete the circuit that trips out the breaker. In another type of small capacity, adjustment is made by using taps on the winding; however, this cannot be done in capacities

of several hundred amperes. The great advantage gained by the simple relay described further on in this article has discouraged the use of plunger-type relays on direct-current circuits. If a plunger-type relay is to be used with a shunt, as has been done in rare cases, the adjustment for load is made by varying the drop of the shunt.

In Fig. 7 is shown a type of simple overload relay which is connected by circuit to a shunt. In the diagrammatic scheme of parts, Fig. 9, the iron armature *A*, carrying the contact *B* and pivoted at *C*, is held in its normal position (contacts *B* and *D* open) by the tension



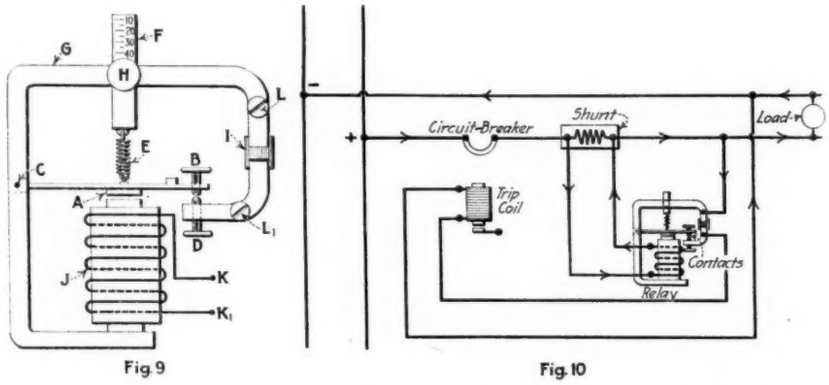
FIGS. 7 AND 8. SHUNT-TYPE OVERLOAD RELAY AND CIRCUIT-BREAKER WITH OVERLOAD SHUNT-TRIP COIL

of the spring *E*. This spring is attached to an adjustable arm *F* secured to the frame *G* by the thumb-screw *H*. Arm *F* carries a scale calibrated in millivolts. The arm that carries contact *D* is insulated at *I* from the main frame *G*. The terminals *K* and K_1 of the coil *J* are connected to a shunt which is in series with the line, and therefore takes a current proportional to the main current. If the relay is set for 50 millivolts, then, when the current in the shunt produces a drop of 50 millivolts, the armature *A* is attracted, closing the contacts *B* and *D*, which closes a circuit from *L* and L_1 to the circuit-breaker's trip coil.

In the circuit-breaker, Fig. 8, contacts *A* and *B* carry the main current and are arranged to open the circuit in the regular manner. But on the side of the breaker is an electromagnet *C* wound with a large number of turns of fine copper wire. When this coil is energized, it pulls up the plunger *P*, which strikes the trigger *F* and releases the operating arm at *D*, thus releasing the moving contact *A* and allowing the breaker to open. Fig. 10 gives the diagram of connections of the relay and circuit-breaker under normal load, the path of the currents being shown by arrowheads. An overload causes the relay contacts to close the trip-coil circuit to the breaker and the latter opens the circuit, thus relieving the overload on the system. In installations where the potential trip-coil circuit is connected to the circuit to be controlled, the overload trip attachment on the breaker should always be connected in the circuit, since dead short-circuit on the line may cause the voltage to drop so low that it will not operate the potential trip coil on the breaker. This allows the overload attachment on the breaker to be set high, for protection against short-circuits or other violent disturbances, but the relay is set so as to give protection against moderate overloads.

The relay has a more important duty, however, than simple excess-current protection. Suppose, for example, a motor is driving a machine that strikes a hard spot in the work and then is released after a very short period, or an accidental short-circuit occurs on the line and is burnt off in a flash. Either one of these causes produces an excess current which might trip the breaker, thus stopping all work until it could be reset and the machines started again. But the excess current came on and off in so short a period that no damage was done. It would have been better if the circuit-breaker had stayed in two or three seconds, and then if the current dropped to normal in this time there would be no interruption. On the other hand, if the overload continued there would still be ample time to open the circuit before any damage could be done. This is the function of the time-limit relay; it delays the opening of the circuit-breaker a definite period after the instant of excess current, thus allowing time for the current to drop to normal, if the fault is cleared within the time setting of the relay.

Fig. 11 shows a definite-time relay with the cover removed and Fig. 13 gives a schematic diagram of parts. The solenoid *A* has an iron plunger *B* which under normal condition rests on the moving arm *C*, pivoted at *F*, which carries a contact *D* and a counterweight *E*. When the solenoid *A* is energized, the core *B* is raised upward instantly; relieved of this weight, the counterweight *E* now causes the contact *D* to start upward to meet the upper contact *G*. However, attached to the arm *C* is a piston *H* working within a cylinder *I*, which retards the movement of arm *C*, making it move very slowly as the air escapes around the plunger. Then, after a definite time, from 1 to 5 seconds, depending in the initial distance between contacts *D* and *G*, the contacts *D* and *G* close, thus closing the circuit to the shunt-trip coil of the circuit-breaker, causing the latter to open.

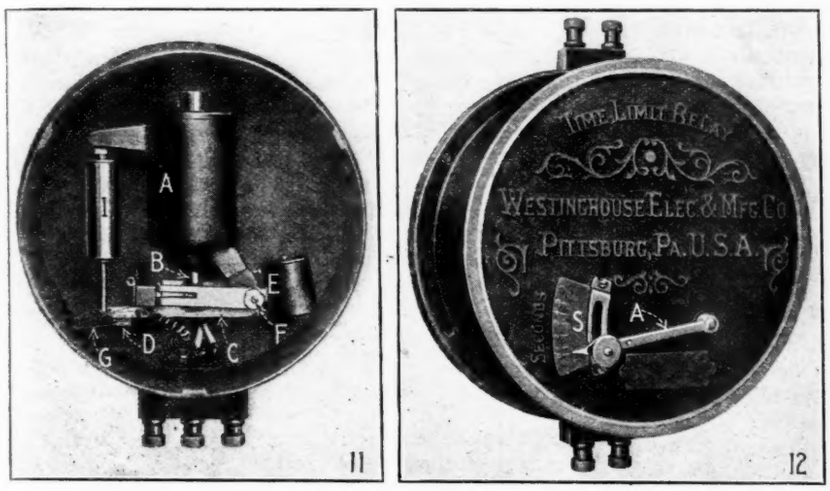


FIGS. 9 AND 10. DIAGRAM OF SHUNT-TYPE OVERLOAD RELAY, FIG. 7, AND RELAY CONNECTED IN CIRCUIT

If the current drops to normal before contacts *G* and *D*, Fig. 13, close, the solenoid allows the plunger *B* to drop, thus forcing the arm *C* downward into normal position. In order that the relay may reset quickly, a valve is provided in the dashpot plunger. This valve consists of a little steel ball *J*, which closes the air ports *K* when the piston moves upward and attempts to force air out of the port, but raises and allows the air to enter readily when the piston moves down as in resetting. An outside view is given in Fig. 12 of a definite-time-limit relay similar to that in Fig. 11. This relay will close the circuit in the number of seconds that arm *A* points to on scale *S*.

The types of relays Figs. 1 to 5, if desired, may close the circuit to a definite-time-limit relay instead of tripping the breaker instantly, but then, while the action is selective the cost renders its use prohibitive. Selective action, except in very heavy short-circuits, may be obtained by lagging the time of the tripping, and making the relay an inverse-time-limit device. That is, the greater the overload the quicker the time. In fact, in actual practice, the instantaneous relay has a very limited use; an inverse-time-limit relay costs only slightly more, gives the same protection and will not interrupt service on transient short-circuits. The latter type is shown in Figs. 14 and 16. The plunger, in rising, compresses the air in the leather bellows *B*, which resists its upward movement. In the top of the casting to which the bellows is attached, is an air passage *C*, which may be partly or entirely closed by turning the screw *S*. If the air passage is entirely open, the action is almost instantaneous on moderate overloads, but if closed, the time may be anywhere from 1 or 2 sec. to 20 or 30 sec.

The greatest objection to the bellows-type relay is that the leather, unless carefully attended to, will dry out and crack, making the permanence of time setting very unreliable. To secure the best operation the bellows should be rubbed with neatsfoot oil every few months, and load-time curves taken. Otherwise the relays may fail at a critical time. Another fault is that, while the time is inverse up to certain overloads, on short-circuits the time is almost instantaneous. Therefore if applied to a radial-feeder system, the action will be selective up to certain overload, but above this a breaker near the generator may go out as quickly as a breaker near the source of disturbance. To overcome this difficulty, a plunger type, overload, definite-time-limit relay was devised.



FIGS. 11 AND 12. DEFINITE-TIME OVERLOAD RELAYS

A definite-time-limit relay is shown diagramatically in Fig. 15. The plunger *A* is not rigidly attached to the stem *B*, as in the type previously described, but slides freely on it. If an overload occurs the plunger is raised and compresses the spring *C*, which in turn forces the stem *B* upward against the resistance of the bellows *D* and finally closes the contacts *E* and *F* with the disk *G*. It will be readily seen that no matter how severe the overload may be, it can only compress the spring *C*; consequently, the upward pressure on the bellows stem is constant regardless of overload, and the time is therefore constant. The duration of time is varied by opening or closing the air valve *S* as described for inverse-time-limit types. At the first glance this might appear the solution of radial protection, but it is impossible to depend on the relay for closer settings than 1 sec.; therefore, when there are four or five relays connected in a circuit those near the generators must be set to operate in about five or six seconds, which is too long a time to sustain a dead short-circuit, especially near the generator. Then, too, the relays would trip just as quickly on a moderate overload as on a heavy

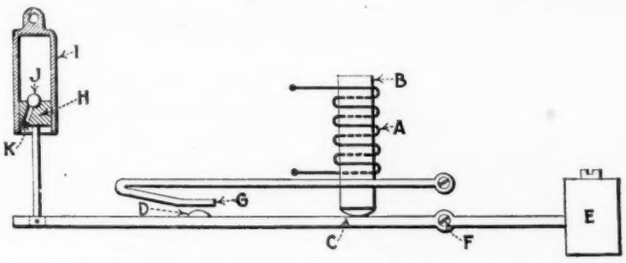


FIG. 13. SCHEMATIC DIAGRAM OF THE DEFINITE-TIME-LIMIT OVERLOAD RELAY, FIG. 11

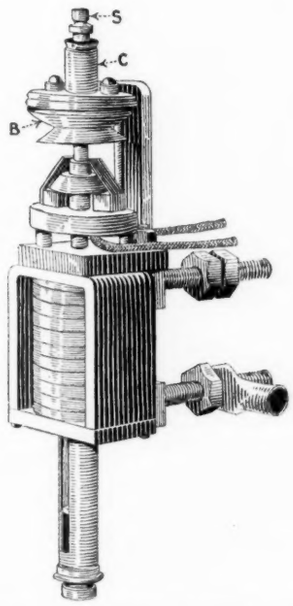


FIG. 14. INVERSE-TIME-LIMIT OVERLOAD RELAY SERIES TYPE

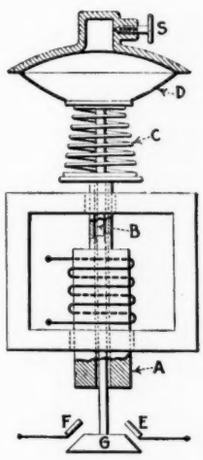


FIG. 15. DEFINITE-TIME-LIMIT OVERLOAD RELAY PLUNGER TYPE

overload, which is not at all desirable. Were the foregoing of great importance, it would be necessary to perfect a relay accurate within small percentage of sustained accuracy and one whose curve was inverse up to certain overloads, after which it would become a definite-time-limit device. However, owing to the unquestioned superiority of alternating current for high-tension long-distance transmissions and the comparatively small size of most direct-current radial systems of transmission, relay engineers have devoted most of their energies to the perfection of alternating-current relays which are to a high degree perfect in their protection. In large power plants or factories, however, where there are numerous machines that must be kept running unless actually damaged, a radial system of protection may be adopted with success.

FIG. 16. INVERSE-TIME-LIMIT OVERLOAD RELAY

This brings up an important use for definite-time-limit relays. Consider the distribution system shown in Fig. 17. Each time the line divides to supply a set of feeders, a definite-time-limit relay is supplied to operate a double-pole circuit-breaker. For instance, the feeder from the busbar is protected by breaker *A*, the next subdivisions are protected by breakers *B* and *C*, and the next by circuit-breakers *D*, *E*, *F* and *G*. Suppose a heavy overload occurs on the feeder protected by breaker *D*. The excess current extends all the way

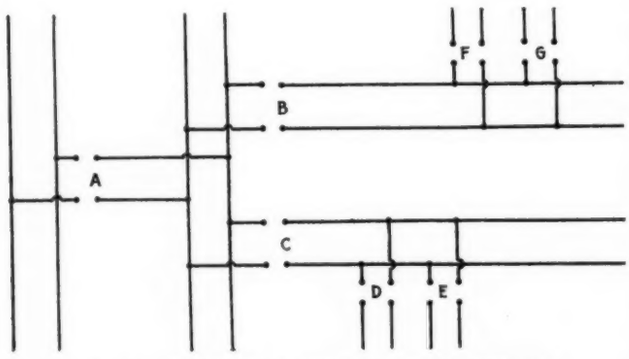


FIG. 17. DIAGRAM OF DISTRIBUTION SYSTEM

back to the main bus, and were definite-time relays not used, breaker *A* would go out as soon as breaker *D*, thus interrupting every circuit connected to the feeder protected by breaker *A*. But this is where the definite-time-limit relay enters in. The relay at *E* is set, say, for 1 sec., *B* and *C* for 2 sec., and *A* for 3 sec. Thus when the disturbance occurs, all the relays of breakers *A*, *B*, *C* and *E* start to operate, but at the end of 1 sec., breaker *E* opens, relieving the excess current, and all the other relays reset quickly, confining the disturbance to the one line on which it occurred. Had the disturbance occurred on feeder *C*, then the breaker at *C* would have gone out in 2 sec.; breaker *A* would not have had time to open and feeder *B* would not have been interrupted. In all the relays so far, we have assumed that the contacts themselves closed the circuit to the trip coil of the breaker, but when the breakers are large and require considerable current to trip them, the contacts of the delicately constructed relays are not heavy enough to safely close the heavy current required. To overcome this difficulty, a relay switch as shown in Fig. 8 is used. This switch consists of a solenoid *S* with an iron plunger *P*, to the bottom of which is attached a loosely held carbon disk *C*, insulated from the metallic plunger. When the overload or the definite-time-limit relay closes its contacts, it closes the circuit to the relay switch, and the energized solenoid instantly pulls its plunger upward, thereby pressing the carbon disk *C* against the two stationary carbon contacts *D* and *D*. Short-circuiting these contacts closes the circuit to the shunt-trip coil on the circuit-breaker. The contacts being of carbon, will carry a heavy current and will not stick. In another form of relay switch, Fig. 19, the plunger simply pushes up a pivoted arm, thus closing the two contacts *D* and *D*.

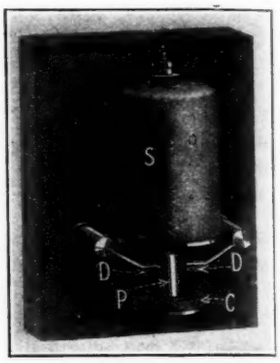


FIG. 18. RELAY SWITCH WITH CARBON CONTACTS

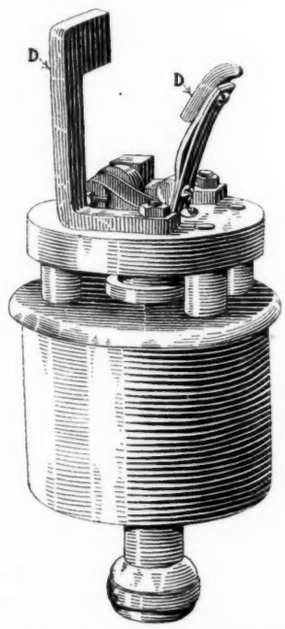


FIG. 19. RELAY SWITCH CONTACTS AT TOP

Sometimes it is desirable to trip two or more breakers at once with the same relay switch. In this case the disk is generally made of copper, and two or three sets of stationary contacts are used, thus closing two or three circuits simultaneously. It must be remembered that the arcing at the relay contacts will always be a great deal more severe when opening a circuit than when closing one. For this reason a relay should never open the trip circuit once established. If the trip circuit is fed from the load side of the breaker, it will be opened automatically when the breaker opens and the circuit will be dead when the relays reset. Should it be necessary to connect the shunt-trip circuit to the line side of the breaker, or if a separate circuit is used, then a switch must be arranged to open the trip circuit as soon as the breaker opens, thus relieving the relay contacts of this duty.

The *Compressed Air Magazine* has attained its 25th birthday and the position of the leading, if not the only, exponent of that important industry. May it live to see many happy and abundant returns.

Steam-Turbine Governors—Governors of Small Westinghouse Turbines

This article deals with direct-shaft governors and vertical-shaft governors for small Westinghouse steam turbines such as are used for pumps and electric generators.

THE Westinghouse shaft governor proper differs little from the usual shaft governor, several of which have been described in the first article of this series. Fig. 1 shows a small Westinghouse turbine, its governor and generator. The governor spindle is moved out with an increase in speed of the turbine and in doing so pushes forward the lever A, Fig. 2. The lever is pivoted at *B* and connects with the stem of the governor throttle valve *C*. On these small machines check nuts are provided on the valve stem to adjust the "play" of the lever and allow a greater or less movement of the governor lever for a given movement of the governor valve. A spring holds the lever against the governor spindle, and the tension of this spring may be adjusted by means of the handwheel.

As with all governors, the operator should see that the governor lever is always free to move easily and that the governor valve stem moves freely in its stuffing-box. Of course the governor throttle should be closed before the governor weights have reached their full travel.

Most small Westinghouse turbines use a vertical shaft, flyball type governor, driven from the turbine shaft through spur bevel gearing or worm and wheel. An exterior view of this governor is shown in Fig. 1, and another view is shown in Fig. 3. The spindle for the oil pump is continued from the governor spindle; the lower casing shows the handhole with cover.

Fig. 4 shows a section of this governor; this view shows only one governor weight (there are two, of course) so that the governor spring bolt may be shown. The weight *A* together with the weight arm *B* is mounted on knife-edges *C* and *D*. The action of centrifugal force is opposed by the helical spring, the tension on which is adjusted by the nut *E*. The governor weights are steel cylinders riveted between the weight arms. Notice that the governor arm block *F* is riveted to the lower part of the governor arm, that it has two knife-edges—*C*, resting on a steel block on the governor weight disk, and *D*, held between two blocks, the lower one in *F* and the upper one in the under side of the governor-spring sleeve *G*, which is loose on the governor spindle and revolves with the spindle. The purpose of the sleeve is to transmit the pressure from the knife-edges to the spring.

The sleeve *G*, in moving up and down under the action of the weights and spring, transmits motion to the governor clutch *H*, which carries the trunnion to which the governor levers which operate the governor throttle valve are attached.

A large nut *J* is screwed on the lower end of the sleeve and takes the upward thrust of the sleeve upon the clutch *H*; this nut has a pin and cotter nut to retain it in position.

There are quite a number of different arrangements of levers for transmitting motion from the governor sleeve to the governor throttle. Fig. 3 is a good view of a typical arrangement. Here the governor case is removed, showing the weights, the top part of the governor sleeve, the spindle, spring, adjusting nut and the governor weight disk.

Adjusting the Governor—The important thing to be sure of always is that the governor valve closes before the governor weights have reached their extreme throw or outer position. This will avoid a runaway.

Changes in speed are had by means of the nut *E* and the governor-spring adjusting-nut seat. The flange of

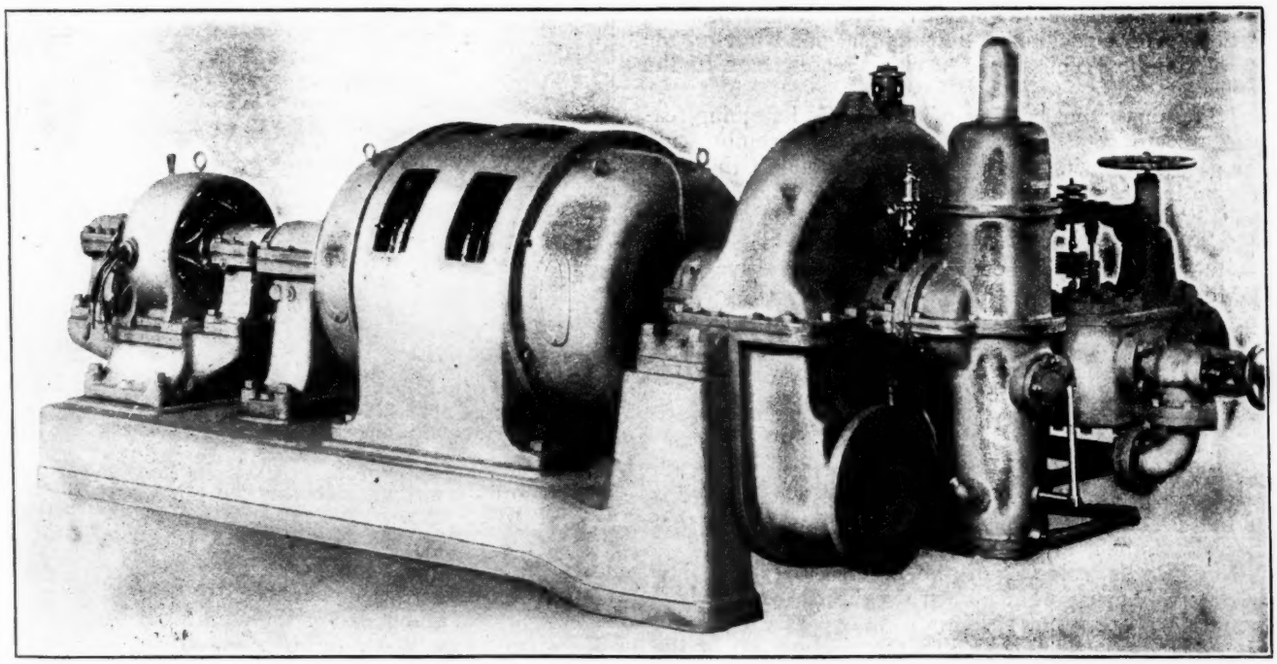


FIG. 1. SHOWING SMALL WESTINGHOUSE TURBINE AND GOVERNOR

the governor-spindle adjusting nut and the adjusting-nut seat have a number of holes into which a pin may be screwed and held in place by a cotter pin. This fixes the adjustment made to the governor. The adjusting-nut seat is held from turning on the spindle by a pin and keyway.

Usually, the first indication of trouble is that the governor hunts. Before disturbing the adjustment of

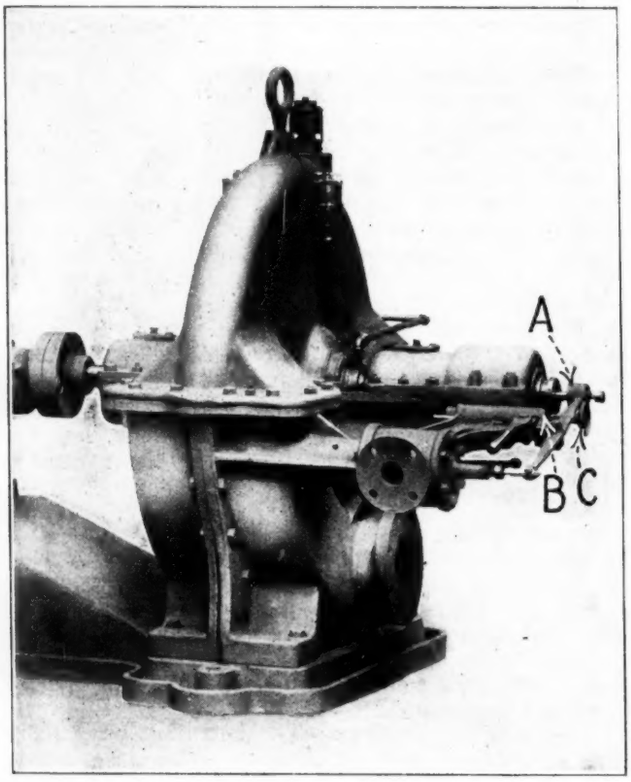


FIG. 2. SHAFT GOVERNOR, WESTINGHOUSE TURBINE

the nut *E* or the adjusting-nut seat, make certain that no parts of the governor, clutch, levers and governor valve stick because of gummed oil, dirt, lack of lubrication, or dry packing or too tight a gland nut on the valve spindle. This means a close examination of the governor.

If hunting is not because of any of the foregoing reasons, try to get the proper regulation by compressing the governor spring by means of the nut *E*. If this cannot be had by this means, cut out some of the spring coils by screwing the spring farther on to the governor-spring adjusting seat. This may be overdone, and if so, the governor will not be sufficiently sensitive.

More coils of the spring are then required, and the spring must be unscrewed from the adjusting-nut seat, a little at a time.

Close regulation may now be had by means of the nut *E provided there is not excessive lost motion in the levers between the governor valve stem and the governor clutch sleeve.*

The Governor Valve—Fig. 5 shows the governor valve and the automatic throttle valve. The former is of the double-disk poppet, balanced type. Notice that the valve is held to its seats by a spring.

The throttle valve is of the automatic type. The valve has a bypass which, when the throttle-valve wheel is turned to open the valve, lifts the bypass valve from its seat, thus putting steam line pressure on top of the throttle-valve seat, putting the valve in balance. Further turning of the handwheel will bring the throttle-valve stem collar *A* against the lower valve-stem nut *B*. This nut is loose and will move up and down.

In Fig. 5 the throttle is closed. When the valve is open it is held in that position by the latch *C*, which may be released by the automatic stop or emergency governor flying out, striking the trigger *D*. When the latch has been released, the spring on the throttle-valve nut forces the valve to its seat, closing it.

If the emergency governor has tripped the throttle or if it has been tripped by hand, the throttle cannot be opened until after the handwheel has been turned in the closed direction until the valve-stem nut is in its upper position and the valve-latch guide rod engaged the latch.

The Automatic Stop Governor—In the lower left-hand corner of Fig. 5 is shown the automatic or emergency governor, which is located in an extension of the governor driveshaft. It consists chiefly of a spring *A* and plunger *B*. Centrifugal force tends to make the plunger fly out; but the spring resists this tendency. When the speed increases the centrifugal force sufficiently to overcome the spring, the plunger flies out, striking the trigger *D*, which will release the automatic throttle valve.

To change the speed at which the emergency governor operates, insert or remove liners from the top of the spring at *C* in the lower left-hand corner of Fig. 5. There is a cotter pin that prevents the nut, which in-

FIG. 3. GOVERNOR WEIGHT CASE REMOVED; SHOWS SPRING, WEIGHTS AND LEVERS CONNECTING WITH GOVERNOR VALVE

closes the spring and plunger, from turning. Be sure this pin is in place after adjusting or taking the governor apart. Pulling up on the flyball-governor valve stem will overspeed the turbine, and if working properly the emergency governor will trip the throttle

within 2 or 3 per cent. of the same speed every time it trips. Note the speed at which the emergency trips; it should be at 10 per cent. above the normal speed of the turbine. If it does not do this, make sure that the throttle does not stick. If it does not stick, then adjust the emergency to trip at 10 per cent. overspeed by the use of the liners already mentioned.

If during usual runs the emergency trips, it is reasonable to conclude that the turbine was overspeeding when

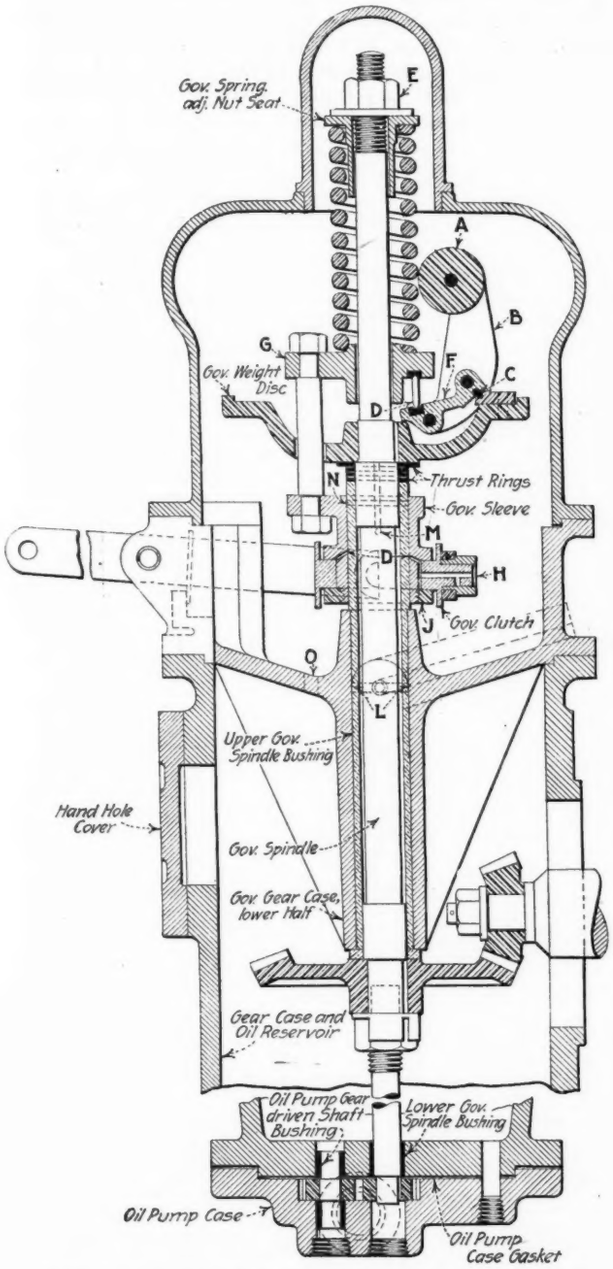


FIG. 4. SECTION OF GOVERNOR USED ON SMALL WESTINGHOUSE TURBINES

it tripped. Take time to find out the cause before resetting the throttle and starting the turbine. This is important, for it may be that the turbine may soon overspeed again and the emergency fail to trip. This will likely cause a serious accident.

Lubrication of the Governor—Oil under pressure is supplied between the spindle, Fig. 3, and bushings through openings at *L*. The oil works up between the spindle and the bushings to a point *M* and then out *N* between the spindle and the sleeve. From here it finds its way through other parts to the trunnions. Some oil also reaches the thrust rings of brass and steel, immediately under the governor weight disk. The oil collects at *O* and from here is led to the gears through a small pipe.

The importance of having a clean and adequate supply of oil and of keeping all oil parts and channels free

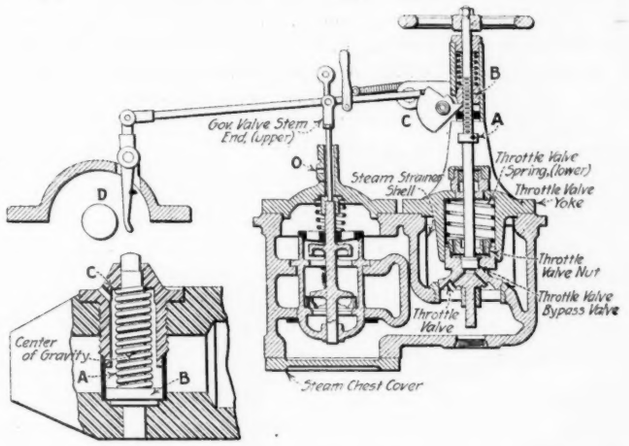


FIG. 5. GOVERNOR VALVE AND AUTOMATIC THROTTLE VALVE

of dirt and gummy oil is obvious. The success of the whole turbine depends upon this, as with any similar mechanism.

Change in the Design of Rotary Converters and Generators

During the year 1919, the Westinghouse Electric and Manufacturing Co. completed service tests to determine the value of oscillators on rotary converters. The tests indicated that the oscillators should not be used. This feature is, therefore, being omitted from this company's standard synchronous converters, and improved results are being obtained.

The compensating winding has been incorporated in the design of all of the generators of the larger motor-generator sets built by this company. The use of this winding has considerably improved commutation over that of the machines having only commutating poles. The compensating winding, in addition to the commutating poles as incorporated in the recent designs, is particularly valuable from an operating standpoint on very heavy peak loads.

Flywheel Governor Bursts

Shortly before five o'clock on Jan. 5, the flywheel governor on a Harrisburg Standard engine at the Lock Haven Silk Mill, Lock Haven, Penn., burst. Fortunately, no one was injured and little damage was done except to the engine.

The governor was of the centrally balanced centrifugal inertia type and had been pounding slightly since a new piston valve with expansion rings was installed on Dec. 21. The engine was direct connected to a 40-kv.-a. generator which had been carrying about 15 per cent. over its rated capacity. The engine was in charge of C. M. Glossner, the operating engineer, at the time of the accident.

Refrigeration Study Course—II. The Ammonia-Compression System

By H. J. MACINTIRE

Professor of Mechanical Engineering, University of Idaho

IN THE first article of this study course an attempt was made to show what refrigeration really is and what means are resorted to to achieve this end. It was shown that refrigeration in nature is common, but in its practical application in appreciable capacity it was necessary to find a new method, one utilizing a vapor like ammonia, which, in changing from a liquid to a gaseous state (at the proper pressure), would boil at a relatively low temperature. Also that it was necessary to use the same refrigerant over and over again, which meant that a pump or compressor would have to be provided to increase the pressure sufficiently high that the gas might be condensed at atmospheric temperature. This process was shown to be similar to the steam-engine cycle, only with the events in the reverse order. The object of the gas pump, or compressor, is simply and solely to increase the pressure, thereby making it possible to condense the compressed ammonia by cooling with water at 60, 70 or 80 deg. F. temperature. Fig. 1 shows a typical refrigerating plant.

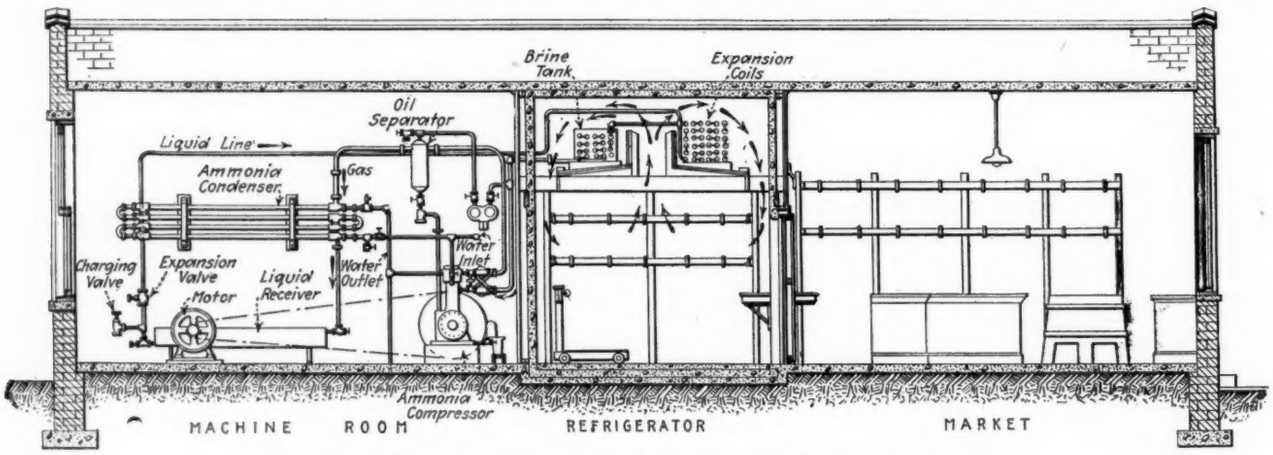


FIG. 1. SECTIONAL ELEVATION OF A TYPICAL REFRIGERATING PLANT

The High-Pressure Side

The reader should understand the reason for the use of the compressor—what it accomplishes and what is expected of it. There is really no unusual feature about it. The dry-air vacuum pump draws in the rarefied air at the pressure maintained in the surface condenser and pumps it up to an amount a little in excess of atmospheric pressure, when it is exhausted out of the condenser. The deep-well pump takes water at the level in the well and lifts it up to the cistern or overflow. In each case work is done on the substance, it is lifted in level (pressure level in one case and datum level in the other). In the case of ammonia we are able to lift it in still another sense—in the temperature level, because by increasing the pressure we can condense the vapor at a relatively high temperature.

As in compressing air, the ammonia gas becomes hot during compression and the discharge gas has a pressure of 125 to 185 lb. per sq.in. and a temperature of between 150 and 250 deg. F. This compressed hot gas is allowed to leave the compressor and pass into a kind of aftercooler, which is a coil of pipe suitably water-cooled so that finally the temperature of the gas is reduced down to within 15 to 20 deg. of the initial temperature of the water. From what has already been said it is clear that long before this has occurred condensation of ammonia has been completed and we have a liquid ammonia under a pressure approximately that of the discharge from the compressor. This liquid is collected into a drum, or header (called a liquid receiver), and is now ready for a second round through the refrigerating coils. The compressor, condenser and receiver are often called the high side.

The liquid ammonia stored in the receiver is under pressure and will flow through the pipe line to the cold-storage room similar in action to the manner of water in a pipe. At the cold-storage room, or brine tank, there is a valve called an expansion valve. It is not an expansion valve at all; it is only a pressure-reducing valve. It has been shown that to get a boiling temperature of zero degrees F., the ammonia must be kept constant at 15.23 lb. gage. So then, the expansion valve allows the pressure to drop from 150 lb. to 15 lb. and the liquid squirts into the coils like water under pressure through a sand hole in a pipe fitting. If the piping is properly arranged and proportioned, it will immediately begin to boil because of absorbing heat through the pipe coils from the air in the room, in consequence of which it becomes vaporized. As a vapor the ammonia has little refrigerating value, and it is allowed to pass out of the coils promptly and return to the compressor, which compresses it again.

The Refrigeration Cycle

And so it will be seen that the refrigeration cycle has three parts—the refrigerating coils, the compressor and the condenser. The refrigerating coils in action are much like the boiler in a steam-engine plant. The coils of pipe are so arranged as to be in contact with relatively hot air. This heats the pipes and boils the ammonia, vigorously or not, depending upon the tem-

perature difference between the air temperature in the cold-storage room and the boiling temperature of the ammonia. Now, in a steam boiler, if boiling took place the steam would accumulate, and unless the engine or some other apparatus took the steam away as fast as it was generated, the pressure would rise until finally the safety valve would blow. On the other hand, if the steam were used too fast the steam pressure would drop and the temperature would be lowered in consequence. That the pressure may stay constant in a steam boiler we have to have means of generating just the same amount of steam as is used each minute.

Likewise the refrigerating plant must be so ordered that the vapor boiled from the refrigerating coils will be just enough for the compressor. If the boiling action is too rapid and more vapor is formed than can be pumped by the compressor, the boiling *pressure* will increase and the boiling *temperature* will likewise increase, perhaps to a point where satisfactory results will not be obtained. On the other hand, too high a speed of the compressor will lower the boiling pressure and temperature and poor results again will be encountered. The cubic feet of piston displacement of the compressor must be inter-related.

For example, suppose we have a room to be held at 36 deg. F. and 500 sq.ft. of cooling coils is supplied. The design allows a suction pressure of 37½ lb., which corresponds to 24 deg. F. boiling temperature of the ammonia. The temperature difference on the two sides of the pipe is 12 deg. F., and in consequence a certain amount of heat will flow through the pipe from the air to the ammonia. The amount will vary directly in proportion to the product of the area of the pipe and the temperature difference. The result is that ammonia is evaporated and it will be given off at the rate of 1.8 cu.ft. per minute.

It may not be clear to everyone that a gas or vapor has weight. Yet in a steam engine the steam condensed may be weighed, and we know that it requires 15, 20 or 30 lb. of steam to produce a horsepower for one hour. Likewise, air has weight, as we know from the successful accounts of the lighter-than-air or "Blimp" airship. So each pound of ammonia evaporated will occupy a certain particular volume, depending on the pressure. For instance, a pound of ammonia at—

200-lb.	gage will	occupy	1.40 cu.ft.
150-lb.	gage will	occupy	1.82 cu.ft.
100-lb.	gage will	occupy	2.57 cu.ft.
30-lb.	gage will	occupy	6.3 cu.ft.
20-lb.	gage will	occupy	8.0 cu.ft.
10-lb.	gage will	occupy	11.0 cu.ft.
0-lb.	gage will	occupy	17.8 cu.ft.

Refrigeration a Matter of Heat Transfer

In the steam boiler it is usual to specify 10 sq.ft. of heating surface per boiler horsepower, and a boiler horsepower as the evaporation of 34½ lb. of water from 212 deg. to dry steam at 212 deg. F. In refrigeration we cannot proceed just like that. The refrigerating coils are really a boiler, but conditions are not always the same. For instance, we may design the coils to have 10 deg., 15 deg., or 20 or more degrees difference in temperature between the inside and the outside of the pipes. The greater the difference in temprature the more capacity may be obtained from the pipe refrigerating surface. Again, the pipe surface may be wet or frosted slightly, or heavily coated with ice. It is not reasonable to expect that the same amount of boiling action will occur in each of these cases, nor in the case where the inside of the pipe is filled with oil. In other words, there is a so-called coefficient of heat transmission for refrigerating piping as there is in all heat transmission piping.

As refrigeration is almost entirely a matter of heat transfer, it is desirable to be able to calculate how this takes place. The equation which we use is

B.t.u.= area of surface in square feet × coefficient of heat transfer × the temperature difference in degrees F. on the two sides of the surface.

The coefficient of heat transfer has to be found experimentally or by experience on similar kinds of work. The following problem will show the method of calculation. Suppose we have a direct expansion pipe composed of 1200 lin. ft. of 1¼-in. pipe. The ammonia boils at 25 lb. gage (11.7 deg. F.), and the room temperature is to be maintained at 34 deg. F. It is required to find the refrigeration to be supplied. The usual value of the coefficient of heat transfer under these conditions is 2.0 B.t.u. per hour, then

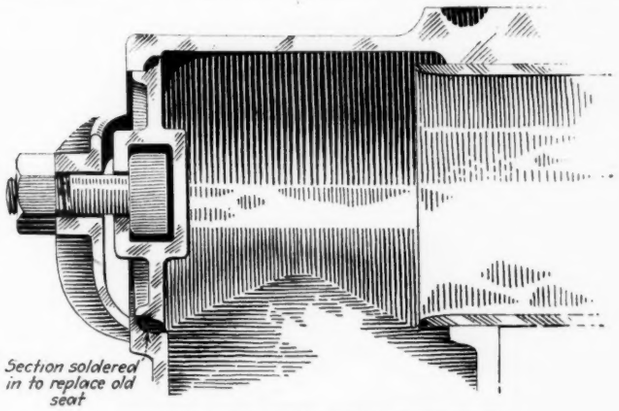
$$Total\ B.t.u = \frac{1200}{2.3} \times 2 \times (34 - 11.7) = 23{,}200\ per\ hr.$$

Steam boiler capacity is defined as the rate of *heating,* or at 33,479 B.t.u. per hr. In like manner we define the standard of refrigeration (the ton) as the rate of *cooling,* but in this case at the rate of 12,000 B.t.u. per hour (or 200 B.t.u. per minute). So, in the foregoing problem the tonnage will be $\frac{23{,}200}{12{,}000} = 1.94$ tons of refrigeration, and a machine would have to be selected which would compress enough vapor to supply this amount of refrigeration. How this may be determined for various conditions will be shown later.

Soldering a Handhole Seat

By Melford Kurtz

On one of the boilers at my plant, having a beveled ground joint seat at the handholes, the covers can be changed only when a tube is taken out, and it is some job to keep this boiler tight. I have used a number of lead gaskets which work very well where the pitting is not too bad in the seat, but a few days ago, after cleaning the boiler, one of the seats was found so badly pitted that the lead gasket could not be compressed in the



WHERE THE SEAT WAS SOLDERED

bottom of the hole. I tried putting in an extra piece of lead, but it leaked and I was forced to drain that element.

After scraping the bottom part of the seat, it was tinned and a shoulder of solder built up. It was then peened and scraped down to the proper shape. The necessary lead gasket was then put in place, the boiler closed up and, after getting up steam, cut in on the line. My troubles are over with that boiler, at least for some time to come.

Steam-Cylinder Lubrication

By W. F. OSBORNE

How to determine whether a steam-engine cylinder has either too much or too little oil. A discussion of the factors which affect the lubrication of the cylinder and of the best kinds of oil for the various conditions. The article concludes with a summary of the points brought out, arranged in numbered statements, and shows by examples how to use this summary to select the proper oil for any given condition.

IT IS not as easy to know when a steam cylinder is efficiently and economically lubricated as it is to check up bearings, because the inside surface of the cylinder cannot be seen or felt if the engine is running. Lack of lubrication in a bearing very quickly shows up by increased temperature. Wear in a cylinder is usually not detected except on an examination when the cylinder head is removed. Cylinder heads cannot be taken off every day, so the tendency is to use plenty of cylinder oil in order to be sure of getting enough.

A perfectly lubricated cylinder will be highly polished and have a glaze over its surface. It will have no rough or dull spots, nor should there be any sign of rust on examination immediately after stopping the engine. The color will vary from a bright iron-white to a light brown or steel blue. When the cylinder head is removed immediately after stopping the engine, there should be a film of oil over all the surfaces thick enough to saturate three or four thicknesses of cigarette papers of uniform thickness of 0.001 in. Even when the engine has stood for several hours, the oil should not be completely evaporated, although of course the film will not be so thick. The stain on the paper should be a clear brown; if it is black or has black particles or streaks, the cylinder or rings may be wearing or the oil is carbonizing. If there are pools of oil lying in the bottom of the cylinder or in the counterbore, too much oil is being fed and the quantity may be reduced. If the cylinder walls are dry in spots or show signs of wear, either too little oil is being fed or the wrong kind of oil is being used.

Examine Cylinder After Engine Stops

It is always important to examine the cylinder as soon as possible after the engine has been stopped, because the heat of the metal may evaporate the oil and the cylinder will appear dry, even though it may have been perfectly lubricated when the engine was running.

Lack of lubrication will sometimes be shown when the engine is running, by sticking valves or groaning sounds from the cylinder. The remedy is to use more oil until an opportunity comes for an examination of the inside of the cylinder to find out the real cause. Economy of lubrication can also be checked up by examining the exhaust steam or the piston-rod leakage. If the condensed steam shows considerable quantities of liquid oil, either too much is being used or the oil is not being properly atomized; if it shows minute drops of oil and is milky in color, we may feel confident that atomization is complete and that we are not feeding too much. When no oil is fed to the piston rod externally and it has a good film of oil on it, which can come only from within the cylinder, we are safe in assuming that we are getting satisfactory atomization of the cylinder oil.

Steam-cylinder oil is used to lubricate the admission and exhaust valves, the cylinder walls, the piston and piston rings, the throttle valve and on some engines the piston- or valve-rod packing. Two methods are in common use, the direct system and the atomization system. With the direct feed the cylinder oil is introduced directly into the steam chest, on top of the valves, or directly into the top of the cylinder. The oil fed to the top of a Corliss valve, for instance, is supposed to spread along the valve surface and lubricate it and the seat. Oil fed into the top of a cylinder is expected to flow slowly down the sides of the cylinder until it is caught by the sweep of the piston and is wiped over the entire surface.

The second method is based on the fact that the steam reaches every part requiring lubrication. The steam is therefore made the carrier for the oil to all the parts. For efficient and economical lubrication by this method the oil must be introduced into the steam at such a point that it will be thoroughly and completely atomized before it reaches the parts requiring lubrication. If any of the oil is carried into the cylinder in a liquid state, it is promptly carried out again by the exhaust steam and is wasted, but if it reaches the cylinder in a finely divided condition, part of it is deposited on every surface touched by steam. The remainder is, of course, carried out through the exhaust with the steam. Practical experience and many comparative tests have demonstrated beyond doubt that the atomization method will save from 25 to 50 per cent. in quantity of oil over the direct-feed method. With this fact firmly fixed in our minds let us consider the various operating conditions that affect the atomization of the oil and the characteristics of cylinder oils that can be used most economically under the different operating conditions.

Point of Introduction of Oil

The first point to investigate is always the point of introduction of the cylinder oil. The ideal place is in the steam line to the cylinder six or eight feet above the throttle valve. If the point of introduction is too close to the cylinder, complete atomization may not be secured; if it is too far away, there is a possibility that the oil will be deposited on the sides of the steam pipe and flow down to the cylinder in a liquid form. On some engines the oil-feed line is extended to the center of the pipe and flattened out in the shape of a spoon, so that the steam will strike it and blow the oil off, thoroughly mixing it with the steam. Another method is to extend the feed pipe across the steam line and perforate it with several small holes. Such an arrangement will provide ideal opportunities for proper atomization of the kind of oil that will best lubricate the valves and cylinders.

Sometimes the location of steam separators or sharp bends in the pipe close to the cylinder is such that the feed line must be introduced much closer to the engine than is desirable, and in many cases it is necessary to place it just above the throttle. This arrangement gives much less time for the oil to atomize before it reaches the cylinder, and larger quantities are required for good lubrication. The efficiency of atomization for such an installation can be improved by using oils that atomize

more quickly, but as such oils also possess the characterisuc of evaporating more quickly from the cylinder walls, they are not always the most economical.

The characteristics of the steam are next in importance, and the pressure, temperature, percentage of moisture, degree of superheat, priming or foaming of boilers, amount of boiler compound carried over with the steam, etc., all have an effect on the kind of oil to be used and the efficiency of the lubrication.

Steam pressure in itself has no effect on the oil, but the temperatures corresponding to the various steam pressures do have a very marked effect. High steam temperatures will evaporate the oil film off the valve and cylinder surfaces faster than low temperatures, thus requiring the use of heavy-bodied oils or larger quantities of the light-bodied oils. The high temperature also thins the oil down and atomizes it more quickly; consequently, the heavy-bodied oils can be atomized satisfactorily and, as they stay on the cylinder walls longer than the light-bodied oils, are more economical. Low temperatures accompanying low pressures will not atomize the heavy oils properly, and low viscosity cylinder oils are necessary. The low temperatures do not evaporate them excessively.

Steam unless highly superheated always contains moisture by the time it reaches the cylinder. Condensation also occurs when the steam is cooled on entering the cylinder and during the expansion stroke. Moisture in steam will wash a pure mineral oil off the cylinder walls so that very large quantities would be necessary to get any kind of lubrication under bad water conditions. It is customary, therefore, to compound the oil with acidless tallow oil or degras when it is to be used for wet steam. The tallow oil or prepared degras saponifies with the moisture in the steam, forming a soap which lubricates the cylinder walls and assists the mineral oil in adhering. If a large quantity of water is drawn suddenly into the cylinder, practically all of the oil will be washed away temporarily and the cylinder will give off the peculiar groaning sound. When the sudden rush of water is over, the saponified oil will form a new film over the cylinder walls much more quickly than a pure mineral oil.

Amount of Compounding Required

The amount of compounding required in the cylinder oil depends upon the percentage of water or moisture in the steam. Compounding adds to the cost of the oil, and as excessively large percentages have no better lubricating value, the lesser compounded oils are used except for the most severe conditions.

It has been the general opinion that engines using a highly superheated steam are hard to lubricate, a situation created very probably by a failure to understand the actual operating conditions of a superheated steam engine. The general practice in the past has been to use a very heavy-bodied pure mineral oil, and uniformly good results have not always been obtained. Complaints have arisen that lubrication has not been good and that there have been carbon deposits.

With a steam pressure of 150 lb. and a cutoff at one-quarter stroke it requires about 200 deg. of superheat at admission to show any superheat in the exhaust. With any less degree of superheat the exhaust steam will be wet, and as we have to lubricate the cylinder on the exhaust stroke as well as on the expansion stroke, we should use the same kind of oil that would be used on any engine operating on saturated steam. When the heavy-bodied oils are used, they are not properly atomized, because most of these engines have the feeds very close to the cylinders.

Large quantities of pure mineral oils are necessary to lubricate the cylinders properly when wet, and this combination of the large amounts of heavy-bodied mineral oil results in the oil being fed to the cylinder faster than it can be atomized and carried away with the steam. Naturally, carbon deposits result from the collection of oil within the cylinder. In any event there is always the possibility that the superheaters may have to be discontinued temporarily and the engine operated on saturated steam, so it is always safer to use only a small percentage of compounding in the oil. In this way satisfactory lubrication can be obtained with a minimum consumption of oil.

Another thing that has a very bad effect on the oil film is alkali which may be carried over from the boiler with the steam. Excessive quantities of boiler compounds, if they get into the cylinder, destroy the oil film even with the most highly compounded oils, and if the condition exists for very long, the cylinders will begin to wear and score rapidly. Careful attention should always be given to the amount of boiler compound in the boiler water.

Sharp piston rings will also sometimes scrape the oil film off the cylinder surfaces and destroy the polish or glaze. Excessively tight piston rings will do the same thing.

Uniformly Loaded Engine Easy to Lubricate

A uniformly loaded engine is always easier to lubricate than one operating under a variable load. A rapidly changing load is more likely to cause boiler priming and a washing away of the oil from the cylinder walls. Lightly loaded engines have a greater cylinder condensation than fully loaded engines and may require a more highly compounded oil. The velocity of the steam through the steam pipe will be slow, and while it will give more time for atomization of the oil it will also give a greater opportunity for increased condensation.

A compound engine offers a very wide range of conditions which it is sometimes difficult to meet with one oil. It is very easy to pick out the right oil for the high-pressure cylinder, and if it is properly atomized the steam will carry the greater portion of it through the receiver into the low-pressure cylinder, lubricating it also. If the oil is not completely atomized, all the liquid portion will be separated with the condensed steam in the receiver and is lost. It is then necessary to feed additional oil to the low-pressure cylinder. It is hard to do this economically because there is seldom any opportunity to feed the oil into the steam line any distance from the cylinder, it being necessary usually to feed it directly into the steam chest, making atomization difficult. On this account some engineers prefer to use a light-bodied highly compounded oil for the low-pressure cylinder if they cannot get proper atomization of the oil before it enters the high-pressure cylinder. This is particularly true when the engine runs condensing.

Kind of Engine Should Have No Influence on the Oil Selected

If proper atomization of the oil is secured before the steam enters the cylinder and if the oil has the necessary compounding and other qualities for lubricating the valves and cylinders, the kind of engine to be lubricated should have no influence upon the oil to be selected. Simple slide-valve, piston-valve, Corliss-valve, compound, horizontal or vertical cylinders, uniflow or counterflow engines, can all be lubricated with equal efficiency if proper attention is given to the steam conditions, completeness of atomization and the operating

conditions of the engine. There is a possible exception in the Corliss valve when the steam does not reach the ends of the valves, and it is then necessary to feed oil directly to them.

When the exhaust steam is used for manufacturing processes or for boiler-feed purposes where the presence of oil woull have a very bad effect, it is necessary to install an oil separator and use an oil that will separate from the condensed steam most efficiently. The compounded oils do not separate well because of the saponification of the animal oil content, and it is customary to use pure mineral oils on such engines and cut the feed down as low as possible.

The exhaust steam from the cylinders of marine engines is condensed and used for boiler feed. These cylinders are vertical and there is very little pressure against the cylinder walls. Usually, they receive no oil at all and depend on the moisture in the steam to lubricate the cylinders. When oil is used, mineral oils are supplied and fed to the cylinders very sparingly.

Having considered the principal operating conditions that affect lubrication, let us now investigate the various kinds of cylinder oils and see what sort of lubrication can be obtained from different grades.

Classification of Steam-Cylinder Oils

Steam-cylinder oils are classed as fire-stock oils, steam-refined oils and filtered oils. The fire-stock oils are the most adhesive, usually have the heaviest body, and are not likely to be as uniform in characteristics or qualities as the other grades. The steam-refined oils are better lubricants, more uniform in quality, are less likely to decompose in use or form objectionable deposits, and are more readily atomized. They are made in a wide range of viscosities, from 90 sec. to 225 sec. at 210 deg. F., and are dark green or brown in color.

The filtered cylinder oils are made by filtering the steam-cylinder oils through charcoal, which brightens the color, making them clear, and removes some of the more adhesive hydrocarbons. This process makes the oils less adhesive on the cylinder walls and renders them more quickly atomized. They also separate from condensed steam more readily than the steam-refined or fire-stock oils.

All three kinds of cylinder oils are used in the pure mineral state and also when compounded with tallow oil or prepared degras. The compounded oils are most satisfactory for wet steam condition as they are not so quickly washed off the cylinder walls. They atomize more quickly than the pure mineral oils, but do not separate from the exhaust steam as readily.

Considering viscosities alone, the lower viscosities atomize more quickly than the higher viscosities or heavier-bodied oils. Incidentally, they evaporate from the cylinder walls quicker. Heavy-bodied oils require higher steam temperatures for complete evaporation but are more adhesive. When properly atomized, they are very satisfactory; but if not thoroughly atomized, too heavy an oil will not lubricate a cylinder unless excessive quantities are used, with the possibility of carbon deposits.

How to Select Oils

With all of these factors to consider, it is impossible to make any fixed recommendations. Determine your operating conditions, study the following data and try to get the kind of oil which best fits your individual engine.

1. Economical and efficient lubrication depends upon the quality of the oil and its proper atomization.
2. Proper atomization depends upon the characteristics of the oil, the point of introduction, the condition of the steam and also on the operation of the engine.
3. Within certain limits the farther the point of introduction of the oil is from the cylinder the more thoroughly will be the atomization.
4. Oil fed directly to valves or cylinders has little opportunity for atomization.
5. On the other hand, if oil is introduced too far away, it condenses on the sides of the steam pipes and may be trapped out in pockets or drains.
6. Any device placed within the steam line which assists in atomizing the oil is of benefit.
7. High steam pressures because of their high temperatures atomize the oil quicker than low pressures and low temperatures.
8. High steam velocities atomize oil quicker than low velocities.
9. Low velocities give a longer time for atomization before the oil reaches the cylinder.
10. Low-viscosity cylinder oils atomize more easily than high-viscosity oils.
11. Filtered cylinder oils atomize more quickly than non-filtered cylinder oils.
12. Nonfiltered cylinder oils adhere to cylinder walls better than filtered cylinder oils.
13. Heavy-bodied oils stick to the cylinder walls longer than light-bodied oils.
14. Light-bodied oils evaporate from hot cylinder walls when engine is shut down quicker than heavier oils.
15. Water washes oil from valve and cylinder surfaces.
16. Moist steam therefore washes the oil off the valves and cylinder walls.
17. Light loads are accompanied by greater condensation in the cylinder and require more oil.
18. Heavy loads may cause boiler priming, and the water carried over with the steam washes the cylinder oil off the walls and valves.
19. Boiler water heavily loaded with boiler compounds carried over by the steam quickly destroys the lubricating oil film.
20. Any means of keeping excessive water out of the cylinders will improve lubrication.
21. Compounded cylinder oils containing tallow oil or degras saponify in the presence of moisture and do not wash off the cylinder walls as quickly as pure mineral oils.
22. Compounded oils therefore are more economical for saturated steam conditions.
23. Mineral oils may be used for dry or superheated steam when exhaust steam must be freed from oil.
24. Compound engines using superheated steam should use compounded oil on account of condensation in the low-pressure cylinders.
25. Compounded oils do not separate quickly from exhaust steam.
26. Mineral cylinder oils separate from exhaust steam more quickly than compounded cylinder oils.
27. Filtered cylinder oils separate from exhaust steam more quickly than nonfiltered oils.
28. Mineral oils are used where exhaust steam must be freed of oil.
29. Cylinder oils may be classed according to viscosity as follows:

Light bodied	95 sec.-115 sec. viscosity at 210 deg. F.
Medium bodied	115 sec.-135 sec. viscosity at 210 deg. F.
Heavy bodied	135 sec.-160 sec. viscosity at 210 deg. F.

As an example of the use of these items in selecting oils, let us assume the following conditions: Steam pressure, 150 lb.; moisture, considerable; point of introduction of oil, 6 ft. above throttle; boiler water, bad; load conditions, variable; type of engine, Corliss cross-compound condensing.

Analysis—Conditions are good for atomization as steam temperature due to high pressure is fairly high, and ample time is given with feed six feet from throttle.

Conditions are bad for maintenance of oil film on cylinder walls on account of variable loads, bad boiler water, wet steam and operating condensing.

Consequently we would use nonfiltered (12) highly compounded (21-22) heavy-bodied (13) oil and feel confident that it will be economical and efficient (3-7).

Another set of conditions might be as follows: Steam pressure, 100 lb.; moisture, very little; boiler water, good; point of introduction, directly on valve; load conditions, steady-rated capacity; type of engine, simple noncondensing; use of exhaust steam, boiler feed, open heater.

Analysis—Conditions are poor for atomization. Steam temperature due to low pressure is low, and little time is given with feed directly on valve.

Water conditions are good, and there is comparatively little moisture in the cylinder. Exhaust steam must rapidly be freed from oil. Accordingly, we would use a light-bodied (10) filtered (11-27) cylinder oil having low percentage of compounding.

These illustrations serve to show the impracticability of making a general positive recommendation of one or two brands of oil. The most satisfactory way is to examine the individual installation and select the kind of oil to meet that particular class of conditions and operation.

Emergency Automatic Controller

By B. A. Briggs

When an automatic controller on a pump or air-compressor motor must be taken out of service for repairs, a temporary controller can be made from an ordinary starting box having four binding posts. In this type

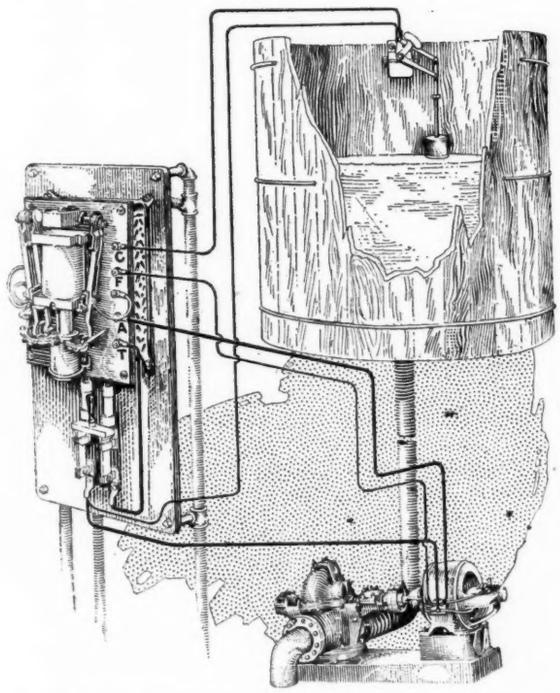


FIG. 1. CONNECTIONS FOR CONTROLLING PUMP MOTOR AUTOMATICALLY

of starter the no-voltage release coil is connected across the line and not in series with the shunt-field windings as in the three-terminal type. In Fig. 1 is shown a type of automatic starter in common use for automatically stopping and starting pump and air-compressor motors. The figure gives the connection for controlling a pump

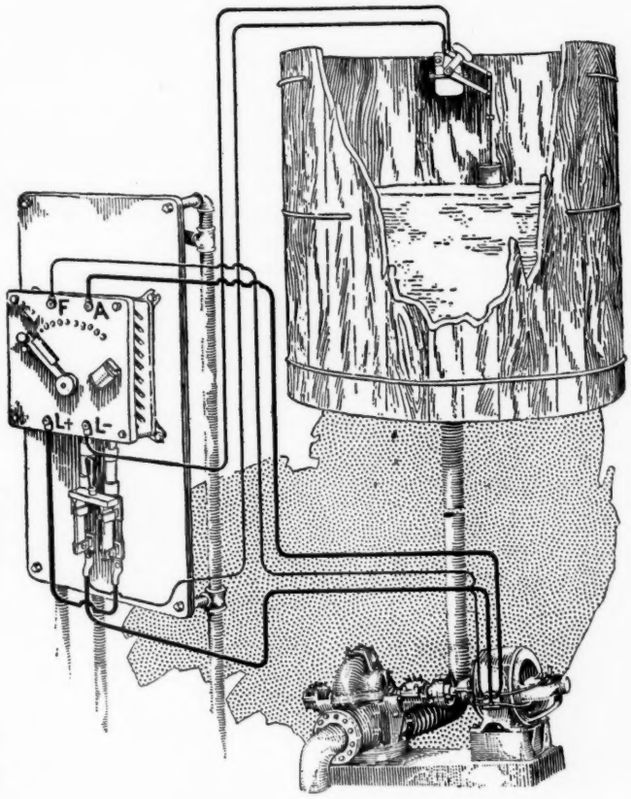


FIG. 2. CONNECTIONS FOR CONTROLLING PUMP MOTOR WITH STARTING BOX

motor through a float switch operated from a float in the tank. When the float switch closes, the solenoid coil on the controller is energized, which in turn closes the contact and brings the motor up to speed automatically. When the tank is full the switch opens, deenergizes the coil, and allows the contactors to open and shut down the motor.

In Fig. 2 the controller of Fig. 1 has been replaced by an ordinary starting box with four terminals. With this arrangement the motor will not start up automatically when the float switch closes, but will be shut down automatically when the float switch opens. If the water in the tank is at a level where the float switch is closed, when an attempt is made to start the motor, the starting arm will be held in the full-on position by the no-voltage release coil. When the tank has been filled and the float switch opens the no-voltage release-coil circuit, the starter arm will be released and the motor shut down automatically. However, if when the attendant started the motor, the water in the tank was at a level where the float switch was open, then the no-voltage release coil would not hold the starter arm, thus indicating to the attendant that the tank was still full. This scheme, although not starting the motor automatically, does stop it automatically and also gives the attendant an indication of the height of the water in the tank when he goes to start the motor. This is generally all that is required of a temporary controller on a pump or air compressor. Therefore, the foregoing scheme can usually be used to good advantage when the automatic controller is being repaired.

Developing the Chain-Grate Stoker

By H. F. GAUSS
Chief Engineer, Illinois Stoker Company

The application of forced draft has resulted in much higher rates of combustion, reduction of ignition troubles, better air control to the various sections of the grate and less leakage of air into the furnace. Securing of prompt and vigorous ignition and the reduction of air leakage have been interesting problems.

IN THE design of a successful stoker the most pertinent problem is to obtain prompt and vigorous ignition. It is a common assumption that this is entirely up to the ignition arch. This function of the ignition arch is by no means to be depreciated, but the entire responsibility for lack of good ignition is not to be placed upon the arch alone.

An inherent characteristic of a fuel bed ignited from the top is that the ignition must penetrate down in an opposite direction to the flow of gases liberated by the combustion of the upper layers. This condition imposes the real difficulty of obtaining successful ignition in the natural-draft chain-grate stoker, and it at once suggests that the draft intensity immediately under the front part of the ignition arch may have a great deal to do with good ignition. Fig. 1 is a typical stoker layout. It is evident that the products of combustion during ignition pass off diagonally as indicated by the arrows. They do not pass straight up and impinge against the arch. In fact, the corner between the feed gate and the front of the arch has no flames whatever.

If one lights a match and holds it in a vertical position with the lighted end up, it burns feebly for a short time and then goes out. Now light a match and support it in the same position as before, but place a piece of red-hot iron a few inches above it. The match now does not go out. However, a slight current of air from the side, giving the products of combustion a diagonal direction in leaving the match, will easily extinguish the flame. This latter condition is obtained in the ordinary natural-draft chain-grate stoker, and unless proper provision is made to overcome it, the result is invariably poor ignition.

There are a number of ways in which the necessary provision to maintain good ignition can be made. It is primarily essential that the fuel be properly prepared. If a furnace is designed and intended to burn 1½-in. screenings, good results cannot be obtained by attempting to use 2-in. nut coal. Neither can good results be obtained by dumping coal for this stoker, after crushing it to 1½-in. size, into an overhead bunker, so arranged that all the fine coal accumulates in the center of the bunker directly over the outlet, while all the coarse coal rolls off the sides to be fed down last with no fine coal whatever. When this condition exists, as it frequently does, the first of the fuel fed down from a freshly filled bunker is so fine that it is almost impossible to ignite it except in a thin fuel bed, owing to its resistance to the passage of sufficient air to support combustion. The fuel then gradually approaches the proper condition, and it becomes necessary to thicken up the fire until the depth originally intended is reached. If conditions would stabilize here, all would be well, but the fuel continues to become coarser and the thickness of the fire must be increased correspondingly until the limit is reached, and then trouble with ignition begins again. It is understood, of course, that the trouble experienced in igniting coarse coal is caused by the fuels becoming so coarse that the small resistance of the bed to the passage of air permits too much air to rush through. Igni-

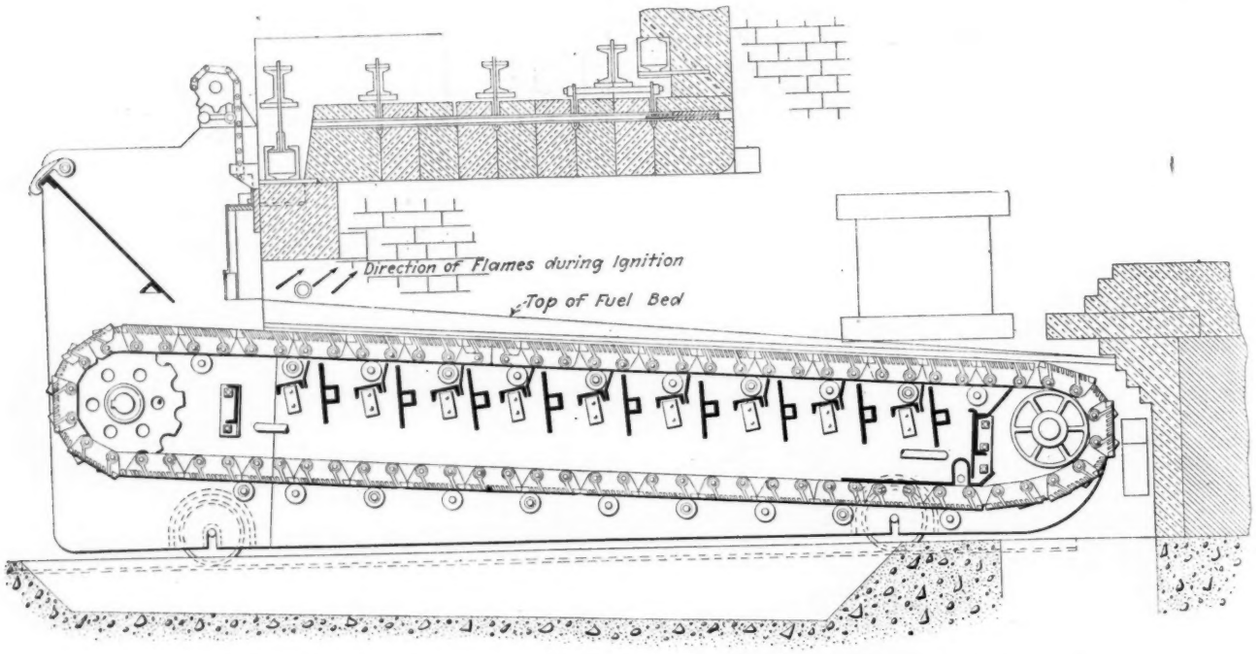


FIG. 1. CHAIN-GRATE STOKER WITH FLAT ARCH, SHOWIN G DIRECTION OF FLAMES

tion is retarded instead of being maintained at a sufficiently rapid rate to permit the necessary grate speed for the capacity demanded. Adjustable dampers extending under the coal hopper in front and under a few feet of the ignition zone of the stoker will aid materially in controlling the air for ignition and permit burning coarse coal under the bunker conditions just described.

Someone will say, "Why not check the damper in the breeching?" This is a good suggestion, but the capacity of the boiler would also be cut down, and no stoker company could afford to design a machine that had to be operated in this way. The real solution of the difficulty is to provide a bunker and coal conveyor so designed that the coal will be uniform in size and condition when fed to the stoker. Unfortunately, the stoker designer seldom has much to say in regard to the arrangement of bunkers and conveyors.

The writer recently saw an expedient resorted to for the purpose of overcoming the difficulty just described, which consisted of a ¾-in. steam pipe introduced under bridge-wall and front boiler-room wall. This applies particularly to existing settings in which it is desired to put a stoker.

Generally speaking, the function of the arch is, first, to aid in maintaining ignition, and, second, to provide a sufficiently hot zone to consume completely the volatile constituents liberated during ignition. More than this an arch cannot do. Once the coal is thoroughly ignited, it burns when supplied with the proper amount of air, and part of the heat so evolved is utilized in keeping the arch hot. It is the writer's opinion that the shorter the arch in keeping with these two objects, the better. A long arch adds unnecessary restriction to the flow of the gases through the furnace.

Fuel ignited on top must burn from the top. Air passing through from the bottom makes the penetration of ignition slow. The top layer of fuel, first ignited, is first to burn up, and the ash forms on top first. This layer of ash renders the fuel bed more impervious to the passage of air, and frequently retards the combustion of

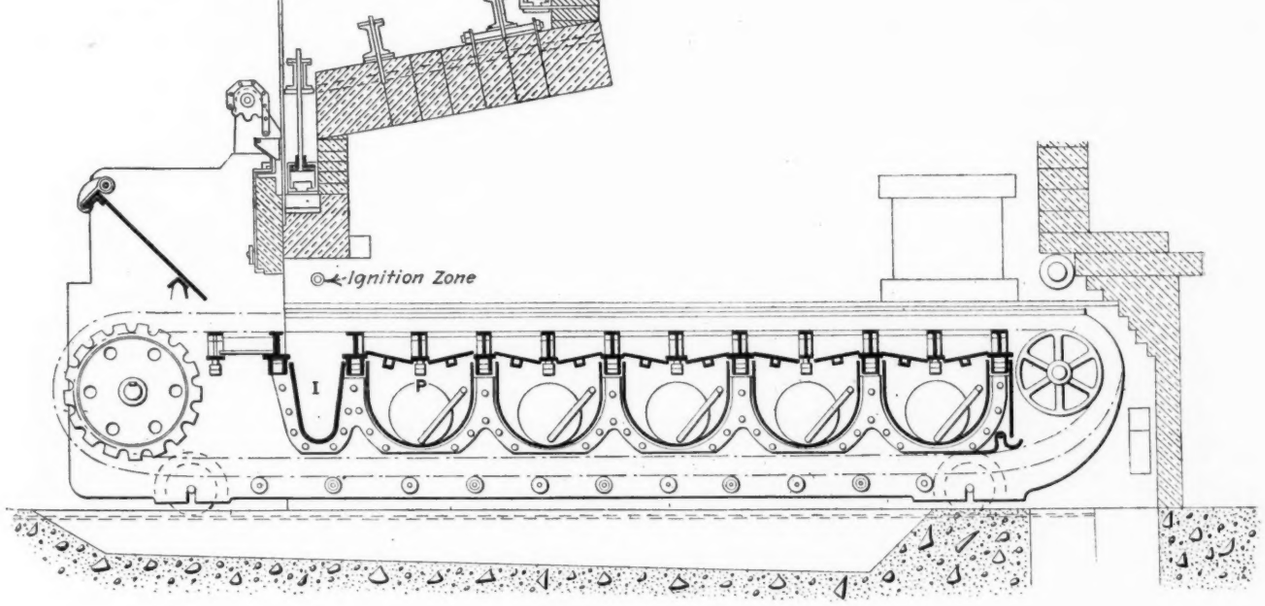


FIG. 2. CHAIN-GRATE STOKER, WITH FLAT TILTED ARCH

the ignition arch about one foot from the front end. Steam admitted at this point caused pressure inside of the furnace sufficient to keep out excess air, and in addition caused the air that was admitted to pass vertically up and impinge against the ignition arch. The device was successful in improving ignition of coarse coal, but its economy is doubtful, when the probable steam consumption of the blower is considered.

The design of an arch is not entirely a matter of mathematical analysis. It is a problem that must be tackled in the light of previous experiment and experience. When a stoker man speaks of designing an arch for burning a particular fuel, he means that he has taken out his notebook, looked up data on arches, which he knows have been used successfully under similar conditions and for similar fuel, and possibly has made a few changes suggested by good judgment. Once successfully designed, it is easy to explain scientifically just why the arch should give the good results sought.

A factor often controlling the length of an arch is the position of the boiler with reference to the ashpit, the lower layers of fuel to such an extent that unburned coal is carried over the rear of the stoker into the ash pit, resulting in a high carbon content in the ash. When this condition obtains, the remedy is a thinner fuel bed and a higher grate speed. The writer has seen stokers burning crushed mine-run bituminous coal of high ash content in which the appearance of the rear end of the grate was such as to lead one to believe that combustion was complete. Upon stirring up the refuse on the rear end of the grate with a rake, a layer of unburned coal was found underneath the ashes, and upon agitation it began to burn fiercely. There is no question but that the ash formed first on top. The writer had the same experience in burning lignite and anthracite culm.

Anyone who has the opportunity to observe the process of ignition through the small inspection door generally provided in the side wall for this purpose, will be able to see with the aid of a darkened glass exactly how ignition takes place.

When just inside the feed gate, the pieces of fuel on top give off tiny volumes of gas and vapor, become red,

burst into small flames, and finally become incandescent. At the same time the particles in the layers of fuel underneath begin to undergo the same operation. The process necessarily requires time, and the fuel cannot be considered thoroughly ignited until it has traveled into the furnace at least 4 to 6 in., and more often as much as 12 in. is necessary. The process is not in the nature of an explosion. An explosion is intensely rapid combustion, which is completed in a fraction of a second. If ignition is complete within 4 in. of grate travel, at the rate of 4 in. per minute, it would require an interval of exactly one minute.

As the fuel advances into the furnace the fixed carbon is ignited, burns up and leaves on the grate a residue which often is thin in spots and likely to permit excess air to enter unless the rear sections of the stoker are provided with adjustable dampers to prevent it. Dampers of this kind are valuable for the purpose just mentioned, but when installed they must receive proper care from the attendant in order to be effective.

After the rear air baffles in the stoker and setting have been made as tight as possible, and even though the ashpits are well made and provided with tight doors, there is likely to be some air leakage between the bridge-wall and the rear end of the grate. To reduce this leakage to a minimum a waterback is recommended. As far as air leakage is concerned, either a closed or an open type of waterback is equally effective. From the standpoint of economy a closed waterback is to be preferred. In cases where there is a demand for hot water, an open waterback is probably the cheapest to maintain and is preferable. In addition to preventing air leakage the waterback is valuable in reducing bridge-wall maintenance by preventing the adherence of clinkers to the overhanging nose and the breaking of the nose tile when these clinkers are sliced off.

In locating the waterback it is essential that it be placed sufficiently high above the rear end of the grate to allow the ash to pass under without touching it. When the ash is allowed to roll up against the waterback, it piles up against the bridge-wall. The writer has seen cases in which just this condition has caused ashes to climb entirely over the bridge-wall of a horizontally baffled boiler and drop into the combustion chamber. A condition like this evidently cannot be permitted to exist, and there must be sufficient clearance under the waterback to let the ashes through. It is not possible to compress an ash bed by attempting to crowd it under a waterback.

A waterback so designed that its vertical height may be adjusted to suit the thickness of the ash bed is theoretically desirable, but not practically possible, as its location is such that the necessary guides, connections and appurtenances would be a source of endless annoyance and trouble. The alternative would be to arrange the stoker so that the rear end can be raised or lowered. This is more desirable construction than an adjustable waterback, but it, too, presents undesirable features and difficulties that render it impractical.

It is not possible to lay too much stress upon the necessity of using the utmost skill and care in preventing air leakage. All ledge plates, seals and joints must be made and kept tight with this end in view.

Attention was drawn at the outset to the recent development of the forced-draft chain-grate stoker in the statement that it had eliminated many of the difficulties formerly experienced in the design and operation of the chain-grate stoker. These may be enumerated as follows: Ignition troubles overcome; better air control to the various sections of the fuel bed; less leakage of air into the furnace.

Incidentally, it becomes possible to carry continuous loads of from 250 to 300 per cent. of normal rating and maintain 70 per cent. operating efficiencies.

At the present writing no data are available indicating the maximum rate of combustion per square foot of grate area per hour, that can be secured. Tests on a stoker containing 130 sq.ft. of active grate area under a 500-hp. water-tube boiler established a rate of 50.2 lb. of coal per square foot of grate area per hour, during a test embracing a period of 16.4 hours. The rate thus established was limited by the ability of this boiler to take the gases liberated, and not by the ability of the stoker to burn more coal. Any attempt to burn more fuel by speeding up the stoker and increasing the air supply resulted in building up a pressure in the furnace and causing the gases to be forced out of the setting wherever a crack or crevice would permit. Shorter tests have indicated a maximum rate of combustion of 70 lb. per square foot of grate surface per hour.

Returning now to analyze the three advantages of the forced-draft stoker, attention is called to the dead-plate directly under the hopper in Fig. 2. This has a two-fold purpose—it prevents leakage of air from the first tuyere to the atmosphere and incidentally prevents leakage from the atmosphere into the first tuyere.

When burning bituminous coal, the first small tuyere marked *I* is omitted and the dead-plate is extended up to the first large tuyere *P*. It is understood, of course, that the grate slides over the dead-plate. No air is supplied to the coal above the dead-plate. The space above the dead-plate and under the ignition arch is then the ignition zone of the furnace.

Sufficient air is supplied through the remaining tuyeres to burn the required amount of fuel, and the main damper in the breeching is closed until a balanced draft condition exists in the furnace. By this is meant a condition in which atmospheric pressure exists in the furnace. There will then be no tendency for excess air to be drawn into the furnace through any unavoidable crevices around the ignition zone. The products of combustion resulting from ignition pass vertically up and impinge against the ignition arch, which materially aids in maintaining vigorous ignition, as illustrated in the match experiment.

In the final analysis what is accomplished here is the gentle mixing with the fuel of sufficient air for ignition, with a time interval of sufficient duration to allow this ignition to penetrate down into the fuel bed without being interfered with by a rush of air in the opposite direction. Once thoroughly ignited, the fuel burns fiercely upon passing over the first pressure tuyere, *P*, Fig. 2.

When burning such fuels as anthracite culm and lignites, which are hard to ignite, tuyere *I* is retained, but it is connected with an exhaust fan which draws some of the hot gases from the furnace down through the ignition zone of the grate, and this facilitates ignition.

The fact that a balanced pressure is maintained in the furnace accounts for the reduced infiltration of air through cracks or crevices in any part of the setting. Balanced draft is a material aid to the waterback in performing part of its duty. It has been possible to obtain CO_2 as high as 16 per cent. with this type of chain-grate stoker. The flat dampers indicated in the tuyeres in Fig. 2, or dampers frequently located in the thimbles connecting the windboxes into the tuyeres, are the means of regulating the air supply to the various zones of the grate.

The advantages of the forced-draft chain-grate stoker are apparent, and from the rapid strides being made in its efficient development it would appear that there is no end to the possibilities.

EDITORIALS

Hunting for Fuel-Oil Profiteers

WHEN a great industrial nation like ours is confronted with a national coal-strike situation such as we recently partly passed through, everybody becomes more or less panicky. With the experience of the war so lately acquired, the Government, to head off unconscionable coal prices, revived the dormant Fuel Administration—and with good effect. But the fuel-oil division did not again go into action, and as a result our Uncle Sam has been made suspicious, and now he is hunting for fuel-oil profiteers through Attorney General Palmer, whose office is carrying a peak load with Reds and the familiar H. C. of L.

The vigorous fashion in which the attorney general is handling Reds and other law violators has evidently made fuel-oil interests remember the "Stop, Look and Listen" sign. The National Petroleum Association warns its members through its consul general, C. D. Chamberlin, not to charge "abnormally high prices" for fuel oil; the refiners of conscientious Kansas say the brokers and not themselves are to blame for high fuel-oil prices. Clifford Thorne, of whom we had not heard much since the Government took over the railroads, pleaded the case of the Western Petroleum Refiners before the Fuel Administration.

The Government recently began prosecuting the Trans-Continental Oil Company for selling fuel oil at "unjust and unreasonable prices." The prices, it is claimed, were three and one-half to four dollars per barrel.

It is easier to accuse than to convict. The inclination to exploit a crisis is human, though not necessarily just, fair or patriotic. The profiteer fever is in the air, and anybody is likely to get it. It is too early to say whether there has been profiteering in fuel oil. But the "man in the street," the "average man," the persons you refer to when you mean all with whom you talk and hear talk, feel that advantage is taken of high costs to boost prices out of the equitable ratio of costs and prices. Whether it is or not matters not; the public believes it is so, and as long as it finds food to nourish the belief, public officers will have to prosecute and "snoop into one's business."

When one knows that until not so long ago Oklahoma fuel oil sold for a dollar a barrel and that during the coal strike it sold for four dollars a barrel; when one knows that but a short time ago Mexican fuel-oil contracts of three to five years' terms were closed at ninety-two cents and a little over a dollar a barrel delivered to northern Atlantic Coast consumers, while now one cannot close a contract for even three years at less than two dollars and a half a barrel without a sliding price clause which may or may not favor the consumer—when these facts are known, it is a judicious mind indeed that does not conclude that somebody is exploiting a national crisis.

But such evidence is not of itself "worthy," as the lawyers say.

First, the law of supply and demand is up and doing despite parlor economists. Fuel-oil consumption for 1919 is officially put at four hundred million gallons. The estimated maximum production for the United States is reckoned to be under three hundred fifty million gallons. You will pay more for a product than you used to when you want more of that product than you can get.

The Mexican political mess, as it bears on fuel-oil production by foreign oil interests, grows worse instead of better. E. L. Doheny, president of the Mexican Petroleum Corporation, claims that the suspension of operation by Carranza of at least eighteen American-worked wells means that the Shipping Board will not get adequate supply for its ships. There is evidently considerable American capital going into investments in foreign-owned and foreign-worked oil fields, particularly so now when foreign exchange values are so low compared with the dollar.

The refiners at a recent meeting in Washington predicted the Government soon would be willing to pay at least three dollars a barrel for fuel oil. Statistics presented by the Bureau of Mines show the failure of many refiners. The coal market does not seem to warrant belief in any reasonably immediate betterment. The Cummins and Esch railroad bills now before Congress look as though higher rates, perhaps appreciably higher rates, will follow the passage of either.

So conditions tend toward higher and higher fuel-oil prices. If there has been profiteering, the Government may uncover and punish those responsible. It is too soon now to cast stones.

Electrical Maintenance Records

THE value of reliable cost records in manufacturing processes has long been appreciated; this is also true in power-plant operation. However, in the distribution and application of power in manufacturing plants the necessity of a detailed record of each feeder, motor and controller has not been given the consideration that it should have, excepting in isolated cases. In many plants where very carefully kept detail records are the practice in the power plant, the records of motor operation in the plant are practically lacking. Or methods of record keeping that, at first, may to a degree suffice, are now, owing to plant expansion, inadequate to give any intelligent record of what the actual cost of maintenance and repairs of the motors and controllers are or of the change in power requirements by the machines driven by the motors.

A record of motor operation should include the nameplate data of both motor and controller, details regarding the different parts of the machine so that they can be readily ordered when needed. A record should be kept of the amount of time spent in repairing the equipment, the cost of materials used, etc., the length of time the motor is out of service for repairs, also the name of the workman who made the repairs. In addition to this a record of current consumption taken at different periods, especially if taken with a curve-drawing instrument, will be of inestimable value where the equipment is giving trouble. This is all the more valuable if it includes a record of the voltage for the same period and also the power factor if the motor happens to be of the alternating-current type. From this information as comprehensive a report can be made as may be desired.

Well-kept records will be found of great value not only in isolating the maintenance cost of each piece of equipment, but in arriving at the cause of high maintenance costs. The latter may be due to improper applications, changed conditions after the motor has been installed, careless operators, negligent repairmen, etc., any of which are easily determined if proper records are kept. If the cost of maintenance is excessively high because of improper application, a reliable record of the conditions will be one of the best arguments to present to the management to obtain an appropriation to make the necessary changes. It will frequently be found that a change of operators on elevators, cranes, etc., will have a marked influence on the upkeep of the equipment. Just what the exact results are and the remedy can be most readily ascertained when a record of operation is kept. Then, again, the work done by one repairman may not be standing up the same as that done by others. This can be proved only by a record of those who do the work and when it is done. The quality of the same kind of material purchased from different firms must have carefully kept records of performance if an intelligent decision is to be made as to which material is best-suited to the conditions to which it is applied.

Properly kept records are as essential to the intelligent and economical operation of the electrical equipment in a manufacturing plant as they are in the power plant. And the former are much more easily obtained than the latter. The most difficult part is to get such a system started; after it is in operation, it will be found to be well worth any effort that may be required for its maintenance.

Scarcity of Men for an Essential Branch of Industry

A GREAT deal has been written recently about the troubles of the colleges and universities in finding or keeping competent men for the teaching forces at the salaries that such institutions can pay. A new phase of this situation has recently come to notice in connection with engineering-research work. The Engineering Experiment Station of the University of Illinois maintains a number of research graduate assistantships. The duties of these positions require not more than half time, the remainder being available for graduate study toward the degree of master of science. In return for his services to the station the research graduate receives five hundred dollars a year and freedom from tuition fees for any courses he may take at the university.

Recently, largely because of the small salary, the experiment station has had great difficulty in securing competent men for these positions. This situation is regrettable for two reasons. The research activities of the station will be seriously interfered with unless properly qualified assistants are available. Since during the two years' work in these positions the men receive valuable research training, present conditions are likely to curtail the supply of trained research workers.

Just at this time the need for skilled investigation along engineering lines is greater than ever before. Increased productive results from each individual's efforts and more extensive conservation of our natural resources are becoming more and more important. The research worker is the man to whom industry must look for the solution of these problems. Much has been done, but more must be done, and as has been previously pointed out in these columns, the more we have progressed along these lines the more difficult further progress becomes.

In the face of these facts the situation becomes really serious. Apparently, the financial conditions are not likely to improve greatly, as this is only a part of the general college situation. The training received, and the satisfaction that always accompanies investigations of engineering problems, must be relied upon to attract the right sort of men to this work. It is to be hoped that enough men will be willing, and able, to make the temporary financial sacrifice so that the important work of such experiment stations and the supply of trained research men may not be interrupted.

Reinforced Concrete For Stator Frames

WHEN concrete was first suggested as material for ship construction, the idea was looked upon as the dream of a romancer. Nevertheless, concrete ships are now in successful operation. Now the suggestion is made to construct the stator frame and thrust-bearing support of large slow-speed waterwheel generators of reinforced concrete. There are apparently no engineering problems involved which make such an application impossible. When made of cast steel or iron, these parts are not supposed to carry any of the magnetic flux, but to act only as a support for the stator core and in some cases the thrust bearing. Therefore, if the casing can be made of reinforced concrete, it will eliminate one of the difficult problems in manufacturing very large slow-speed waterwheel-driven generators; namely, the construction and transportation of the stator casing.

There is no doubt that reinforced-concrete construction is limited to machines of large dimensions, but these are the machines that present serious mechanical and transportation problems when they are made of cast iron or steel. However, since most of our water powers can be economically developed only by the use of comparatively small units, the use of reinforced concrete for stator frames is apparently very limited, even if its use should be adopted where it could be employed to advantage.

Long vs. Short Boiler Courses

A POINT that has not been brought out by any of our correspondents who are discussing the allowable length of longitudinal seams in boilers was mentioned, not at the hearing of the Boston Board of Boiler Rules, at which the question was also discussed, but in the discussion among the spectators following the hearing. This point was that when a bag occurs, it is likely to go a good deal farther in a large than in a small sheet; and that if the sheet has to be replaced it is much more easily and cheaply done in a boiler made up of small courses than in one having few courses made up of large plates.

The engineer who placed a lantern on top of an old-type bipolar generator and short-circuited the terminals found that it did not require the bursting of a flywheel or the blowing off of a cylinder head to have the machine start something, as with the steam engine, but like the tail end of a hornet, the electric generator, when it is alive, is always ready to sting whenever given the opportunity.

Somebody is determined that there shall be trouble between the United States and Mexico. If it starts, fill up your oil tanks!

CORRESPONDENCE

Regarding Diesel-Engine Trouble

Mr. Fagnan's article on Diesel engines in *Power* of Sept. 2, 1919, page 390, is interesting, portraying, as it does, the difficulties a "trouble man" encounters.

However, I believe that he is somewhat in error in some of his statements. The engines he refers to are evidently old American Diesel or "Type A" Busch-Sulzer engines, since no other manufacturer has built units of the dimensions given. In these engines the clearance between the piston and the cylinder head at the top dead-center is $\frac{9}{16}$ in., consequently it is impossible that the thumping he mentions as occurring in the middle cylinder was occasioned by the carbon deposit on the piston striking the cylinder head as he states.

Without doubt this cylinder did not receive its fuel charge at the proper time, and I believe that the pound was produced either by preignition due to early fuel admission or by delayed combustion resulting from late admission. Since he terms it a thump, probably the latter was the case; as the experienced engineer knows, the sound of preignition is quite sharp and vastly different from the dull thump arising from delayed combustion.

Mr. Fagnan's method of increasing the cylinder compression by shimming up below the piston-pin brasses is open to criticism and cannot be recommended to the Diesel operator. The connecting-rods of the "Type A" Busch-Sulzer were of the design appearing in Fig. 1, and the American Diesel used both Fig. 1 and Fig. 2 designs. Both rods have a marine big end which is separate from the connecting-rod proper. The correct way to alter the cylinder compression is by placing sheet-steel shims between the big end and the rod at the point *A*. Incidentally, this is the method followed on practically all Diesel engines. It avails but little to shim up under the piston-pin brass. The only adjustment to be made here is for the purpose of taking up the wear in the piston-pin brass.

A word of caution to the Diesel operator as to the use of a pencil to locate pounds in an engine may not be amiss. In engines with inclosed frames, such as discussed by Mr. Fagnan, it is almost impossible to determine the location of a pound by using a pencil or similar device. The frame acts as a sounding box, transmitting sounds from one cylinder to another. While it is questionable as to following the advice of the old railroad master mechanic who said that he always located a pound in the side rods of a locomotive by first deciding from which side the sound came and then taking up on the other side, still the pencil method is not much better.

The indicator will reveal whether the pound is the result of faulty combustion, and jumping the several pistons and rods will show if the sound is due to bearing play.

Mr. Fagnan states that on checking the camshaft gear train it was found that the gear had been advanced two teeth. He attributes the faulty fuel ignition in No. 2 cylinder to this. Undoubtedly the gears should have been meshed properly when the engines were installed. Nevertheless, since the fuel valves of No. 1 and No. 3 cylinders were operating properly, the fault was not in the mismeshed gears. By altering the gear timing Mr. Fagnan threw the No. 1 and No. 3 cylinder valves out of correct timing. These had to be altered before the engine would function in a proper manner. With this type of engine the fuel cam nose, when only one valve is improperly timed, should be shifted to obtain correct functioning. If this alteration is not great enough, an offset key in the cam will shift it. The Diesel operator should hesitate a long time before changing the gear timing to obtain a correction for one fuel valve, since in so doing he is altering the timing of all the other valves—in the case under discussion this totals nine valves, including the air-starter valve.

San Pedro, San Domingo. L. H. Morrison.

Determination of Volatile Matter in Coal

Of all the determinations made on a proximate or an ultimate analysis of coal, that least susceptible to close checks is the volatile determination. Variations of 1.5 per cent. to 2 per cent. in running checks on the same sample of coal at the same time are not at all uncommon, and checks of less than 0.3 to 0.4 per cent. are rarely obtained. Much work has been done on this, and Prof. S. W. Parr has shown that most of the variation can be traced to mechanical loss, or to oxidation under the cover. Suggestions have been made for minimizing these losses, but chiefly by means that involve the use of expensive apparatus or of considerable time, neither of which is usually available in the small commercial or power-plant laboratory.

I have, however, found that the suggestions of Professor Parr and of others may be combined to give close checks without sacrificing speed or simplicity, and the determination may be performed without the use of platinum crucibles.

Use a 10c.c. high-form crucible instead of a 25c.c. crucible and weigh into it a one-gram sample. Run three samples for each coal analyzed and add ten drops of kerosene to the sample. Heat slowly at first for two to three minutes with preferably a Meker burner instead of a bunsen burner, tapping the lid occasionally to insure that it sits tight. The crucible should be chosen with tightly fitting lids. Then raise the flame

to full heat and heat the crucible for five minutes longer. Cool and weigh, and from the percentage loss in weight subtract the percentage of moisture. The result will be the percentage of volatile combustible.

I have almost invariably found that this method gives two results that check within 0.1 per cent. and often within 0.02 to 0.03 per cent., and I take the average of these two. The third result will probably be nearly 1 per cent. off, for reasons that I cannot explain.

Decatur, Ill. W. J. RISLEY, JR., Chemist,
McLaughlin Foundries and Machine Shops.

Installing Disconnecting Switches

The article of Mr. Matthews in the July 25 issue of *Power*, in which he takes exception to statements in previous issues on the operation of disconnecting switches, is not entirely correct and is rather misleading. Disconnecting switches may be safely opened under load under certain conditions, but those conditions are not the ones granted by Mr. Matthews; namely, the breaking of the charging current of transformers and transmission lines. This operation more than any other should be held as absolutely beyond the scope of the ordinary disconnect switch and done only with the oil and air-break circuit-breakers designed to make and break such circuits. Even then, breakdowns of the latter type of switches, while interrupting a highly-inductive load, such as that of transformers, have occurred.

In one case the sectionalizing disconnecting switches of an 11,000-volt bus was opened, which had load on either side of the "disconnects," but a supply feeder on only one bus section. The load on the end of the bus was the charging current for a 500-kv.-a. transformer bank. The disconnects, without any barriers between phases, were located in the air chamber underneath the transformers. When the second of the three switches was opened, the arc spread to ground and across all

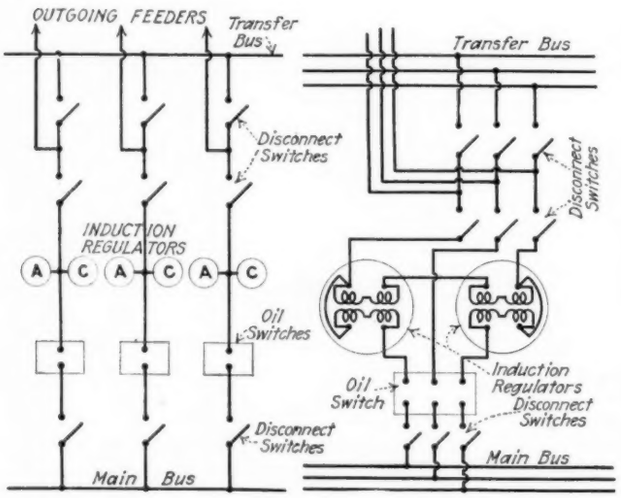


FIG. 1. ONE-WIRE DIAGRAM OF THREE CIRCUITS

FIG. 2. DIAGRAM OF ONE CIRCUIT AND REGULATORS

three phases, burned the switches, shattered the insulators and tripped out the supply transmission line at the generating station more than ten miles away.

Even the charging current of a 25-kv.-a. induction regulator has proved too much for a disconnecting switch. In a substation, where each 2500-volt distribution feeder had selective switching connection through disconnects to a transfer bus, as shown in Figs. 1 and 2, after paralleling two circuits in order to cut out the station apparatus of one of them so that he might work on its oil switch, the operator broke the load current of the circuit at the oil switch instead of at the disconnecting switches, then attempted to break the charging current of the regulators with the latter. The first disconnect he opened broke down under the arc, burned off the cable connected to it, and only because there were barriers between phases, did no further damage except to trip out the oil switches and lose the load of both feeders.

Breaking the charging current of a transmission line has repeatedly proved disastrous to the disconnecting switch at which it was done. In two substations undergoing extensions, temporary 13,200-volt feeders were

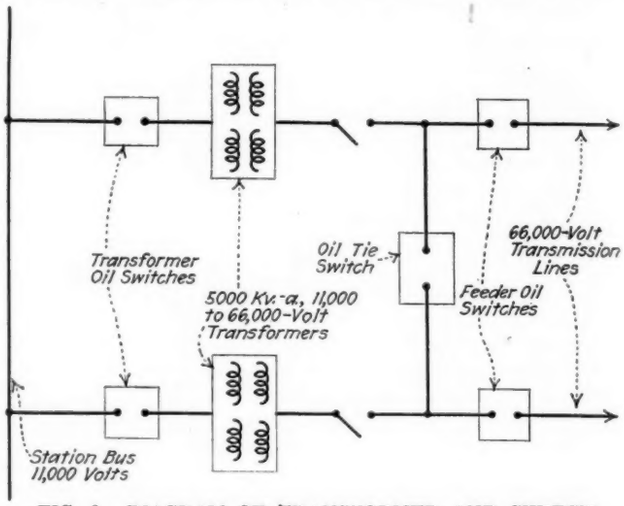


FIG. 3. DIAGRAM OF TRANSFORMER AND SWITCH CONNECTIONS FOR 11,000 TO 66,000 VOLTS

looped into and out of the stations and equipped only with disconnecting switches. Each feeder was made up of three-conductor 350,000-circ. mil. lead-covered cable, and no cable was over five miles long. On several occasions before the real cause was discovered the disconnects broke down while being opened to kill a cable which was carrying no load but its charging currents.

Disconnecting switches may be safely opened under load on a branch of a parallel circuit, where the load of that branch is immediately taken up by another branch and the main load-carrying circuit is not broken; such, for instance, as parallel transformer circuits. Hardly any high-tension alternating-current circuit is noninductive; where an inductive circuit is broken an intense arc is set up, and the disconnecting switch has no way of dissipating this arc.

Fig. 3 shows a transformer installation for stepping the voltage from 11,000 to 66,000 volts. Assume that it is desired to cut out one transformer and still keep both transmission lines energized. After the tie oil switch is closed, the "disconnects" of that transformer are opened, dropping its load over on the remaining unit, after which its magnetizing current is broken at its oil switch.

No accidents would happen if operators properly manipulated their disconnecting switches. The disconnecting switch should be opened very slowly during the early part of its stroke, and when the blade has been brought 0.25 in. to 0.5 in. away from the clips, the movement should be halted to observe the spark at the switch contacts to determine whether it is a load arc or a static discharge; if it is the former, the switch may be immediately closed. When an arc has been drawn in opening a disconnecting switch, it is always safer to close the switch than to attempt to break the arc by opening the switch wider, as that only enlarges the arc.

Barriers should certainly be installed between disconnecting switches, current transformers, potential transformer fuses, and all such high-tension apparatus, since all of it has been known to break down in service. The modern type of construction used in the big central-station systems is to have separate inclosed concrete or albarine cells for each phase on all apparatus, with both the doors of the cells and the cells themselves lettered with the phases and the designation of the apparatus.

FRANK GILLOOLY.

Philadelphia, Penn.

Motor Trouble Was Caused by Brush-Contact Resistance

A single-phase repulsion induction motor gave trouble by not driving its load up to speed as it had done successfully for a considerable period. As the voltage and frequency were correct, the machine was taken apart and thoroughly cleaned and oiled, but this failed to result in an improvement.

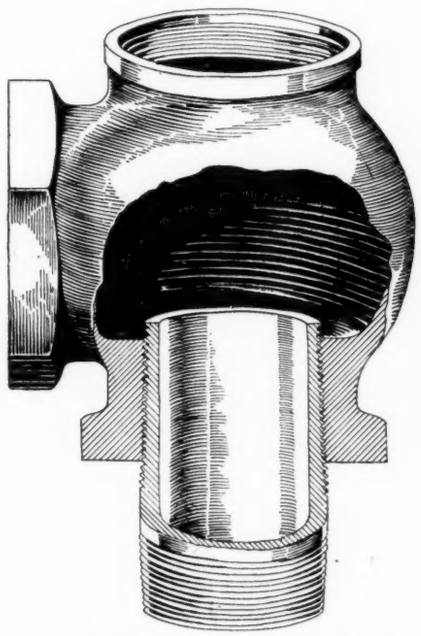
An examination of the brushes showed that they were still of sufficient length, but on account of vibration the copper plating had worn off. After putting in a new set of copper-plated brushes, the machine worked satisfactorily, showing that poor contact between the brushes and holder can cause trouble, especially when the starting conditions are very severe. This at once suggests the use of pigtails on the brushes in order to positively remove trouble from contact resistance in the holders.

HENRY MULFORD.

Patchogue, N. Y.

Reseating an Angle Valve

The exhaust valve that is connected to the top of a pulp-digester cover, through which the acid and steam from the digesters escape, rapidly deteriorates. No acid gets to the lower, or steam, valve and it wears a long



NIPPLE FORMS VALVE SEAT

time, but the life of the relief valve is only about four weeks. Sometimes the body of the valve gives out first, but generally it is the seat. The valves are then scrapped on account of the expense of putting in a new seat.

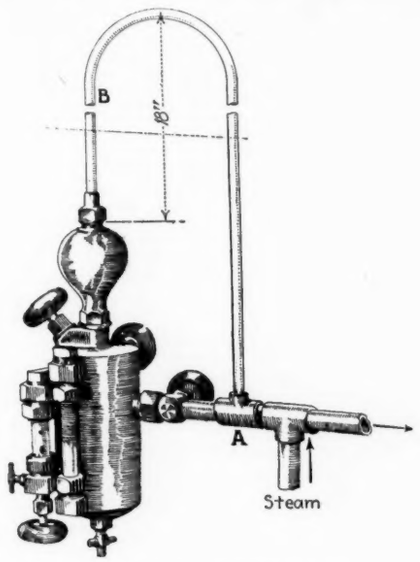
I have recently devised a cheap way of reseating such valves, which gives them from eight to ten days longer life. I simply tap the seat end of the valve all the way through and screw in a brass nipple until it protrudes about one-eighth inch. The end of the nipple being squared off, serves as the seat, as shown in the illustration.

LOUIS J. FARLAND.

Ausable Forks, N. Y.

Changing a Double-Connection to Single-Connection Lubricator

The illustration shows a standard double-connection lubricator, changed to be used as a single-connection lubricator. It was used on the steam-extraction gear



CONNECTION ON LUBRICATOR

of a steam turbine, and as the steam line came in from below, there was no overhead line to tap in on.

The ½-in. by ¼-in. tee *A* was used as shown. A ¼-in. pipe was put in from this tee to the water chamber, this pipe being 18 in. above the top of the water chamber of the lubricator. This gave a sufficient head of water in the leg *B* of the pipe.

Greenville, Penn. GEORGE B. LAMPKIN.

Electrically Welded Stay-Bolt Holes

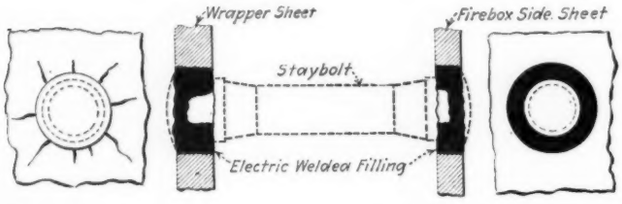
On a certain railroad we experienced a good deal of trouble several years ago from leaks around stay-bolts due to bad water. If a locomotive was equipped with a new firebox, it frequently happened that leaking developed two weeks after the boiler had been returned to service. Inspections of removed stay-bolts showed that the threads were more or less corroded. If the water once has a chance to get around the stay-bolt threads, the corrosive action will be cumulative and will not only lead to a rapid destruction of the threads but also attack the firebox and wrapper sheets and grooving and small cracks will appear, as shown.

In such cases it became necessary to remove the stay-bolts and to drill and lap the holes to a larger diameter. If, after awhile, cracks and grooving developed again, there was nothing left but to remove and replace the whole firebox or wrapper sheet, as it is not feasible to use stay-bolt threads larger than 1⅛ or 1¼ in. in diameter, if the original thread was ⅞ inch.

The introduction of electric welding made it possible

to use a cheaper and more satisfactory method, which may be described as follows:

After removal of the old stay-bolts the holes are milled out in the usual manner; that is, to a diameter large enough to remove all corroded and grooved parts adjacent to the holes. These are then filled up by welding, as shown by the center illustration. It is not necessary to fill them solid, and it is usual to weld until the diameter has been reduced to, say, ¼ or ⅜-in. The opening thus left is then closed on one side by welding a bridge across the hole, so that a punch mark can be made and in order to have an easy start for the subsequent drilling of the new hole, which will be of the same diameter and thread as the original hole.



SHOWING HOW THE STAY-BOLT HOLES WERE WELDED

Compared with the old method, welding offers the advantage that it can be repeated several times without increasing the size of the stay-bolt holes and threads. It is therefore possible to use side sheets and wrapper sheets much longer than heretofore, provided there are no other reasons for replacing them. Welding also obviates the necessity of carrying in stock taps and stay-bolts of various thread diameters. The welding method is now used quite extensively in railroad shops and has given satisfaction from the mechanical and operating standpoint.

H. BLEIBTREN.

Philadelphia, Penn.

Refrigerating Effect of Natural and Artificial Ice

Referring to the letter by H. S. MacDonald on the "Refrigerating Effect of Natural and Artificial Ice," in the Oct. 28-Nov. 4 number of *Power*, I heard a vender of lemonade on a hot summer's day in New York City confidentially declare to a friend of his that natural ice is colder than artificial ice.

There are a number of loopholes to watch out for in a discussion on this subject, one of which is that the meaning of refrigeration be clearly defined. Therefore when Mr. MacDonald asks, "Is there any more refrigeration in a pound of ice that is frozen by nature on a pond, lake or river, than there is in a pound of ice frozen by artificial methods in an ice plant?" the question arises, Just what is meant by refrigeration? Will a pound of natural ice cool an icebox to a temperature of 40 deg. for one hour, or will the pound of natural ice cool the same icebox to a temperature of 35 deg. for three-fourths of an hour? In one case we have longer duration, while in the other we have lower temperature. Which gives the most refrigeration? In the writer's mind the answer depends entirely upon the questioner's meaning.

A pound of snow placed in the icebox will reduce the temperature to a lower degree than a pound of ice, because the snow will melt more rapidly, and snow melts more rapidly because it is more porous.

When considered on a total B.t.u. basis, however, there is no difference. The pound of natural ice contains just as many heat units as the pound of artificial ice provided their temperatures are equal and provided the chemical composition is the same. This chemical composition factor, by the way, was omitted by the editor of *Power*. Perhaps there are other factors or specifications that must be borne in mind while discussing this slippery subject.

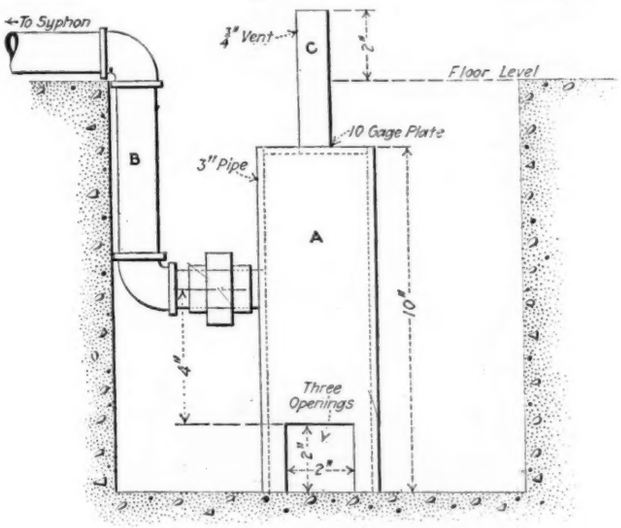
Anyway, of two pieces of ice, one natural and one artificial, of equal volume and equal weight and identical chemical composition and both at the same temperature, the same number of B.t.u. will be required to melt the one as will be required to melt the other.

New York City. W. F. SCHAPHORST.

Saving Oil at the Sump

In many power plants the oil filters are located in a section of the basement, the floor of which is sloped to drain into a sump, from which the water is pumped at intervals by a siphon or pump. The filter-water drains are connected to this sump instead of to the sewer direct, so that any oil leakage from the filter will be retained in the sump. Small leaks at the gage-glasses around the rods of the oil pump and spillage of oil while handling cause a continued seepage of oil to the sump. Owing to the large surface of the sump, a considerable amount of oil will be present in a thin film, and as skimming is a tedious job it will be pumped into the sewer.

To retain this oil in the sump until a sufficient quantity collects to make it worth while to dip it up, we installed

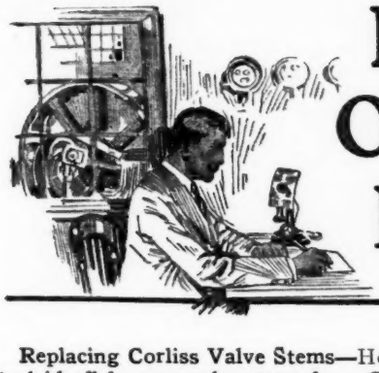


HOW THE OIL TRAP WAS MADE

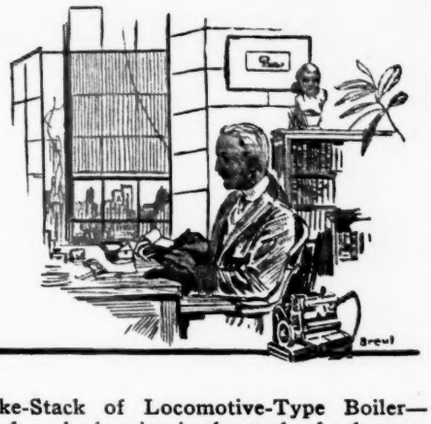
a trap made from pieces of pipe, as illustrated. When the siphon is working, the water enters the 3-in. pipe *A* through the square openings in the lower end and flows to the siphon. When the level in the sump falls below the suction pipe *B* leading to the siphon, air is drawn in through the ¾-in. vent *C*, breaking the vacuum and preventing the oil between the square openings and the suction line from being drawn out of the sump. The storage capacity can be regulated by raising or lowering the position of the suction pipe. An added advantage is that, when using a hose to wash out filters or clean up the floor, the siphon may be left on, and when the cleaning is finished all oil still remains in the sump. This little device saves about two gallons of engine oil a day. At the price we pay, this amounts to about $250 a year.

ADOLPH QUADT.

Perth Amboy, N. J.



INQUIRIES OF GENERAL INTEREST



Replacing Corliss Valve Stems—How would the key seats be laid off for new valve stems for a Corliss engine? J. E. E.

With the old stems in place, uncover the valve bonnets and, with the center mark on the wristplate hub brought opposite to the center mark on the wristplate stud, make a mark on the end of each valve to register with a mark made on the valve seat. Then replace the old valve stems with the new ones, and with the wristplate at the central position and the marks on the ends of the valve registering with the marks on the valve seats as before, and the valve arms in place, scribe off the positions of the keyways from the key seats in the hubs of the valve arms. If the work of marking and cutting the keyways is accurately done, the valve setting will be the same as it was with the old valve stems.

Equal Width Straps for Boiler Joints—What are the advantages and disadvantages of having the same width for the inside and outside straps of a longitudinal butt and double-strap boiler joint? E. L. L.

When both straps are of the same width, each held with the same number of rows of rivets, there is an advantage over unequal width straps in obviating eccentricity of shearing stress of the rivets due to unequal width of straps which has a tendency to bend the shell out of true circular form and thereby introduce longitudinal fracture of the main plate along the edges of the straps.

In American practice this disadvantage of unequal-width straps is assumed to be overcome by the stiffening effect of the broader inside strap. The principal disadvantages of employing straps of equal width are that the joints cannot be designed of as high percentage of efficiency, since for the best efficiency the outer rows of rivets must be spaced too far apart to form a good calking pitch. The latter objection can be overcome only by the expensive process of making the calking edges of saw-tooth form, with rounds and fillets that are more difficult to calk, and the calking edges must be of considerably greater length than straight calking edges.

Chord Factor—What is the chord factor of a coil in an induction-motor winding and how is it figured? C. A.

The chord factor of any coil in an electrical machine generating an electromotive force is a factor representing the effectiveness of the coil in generating voltage. The chord factor is equal to the sine of one-half of the angle in electrical degrees which the coil spans. In a stator core having 72 slots wound for 6 poles, for the coils to span full pitch they would have to span $72 \div 6 = 12$ slots, that is, the sides of a coil would have to lie in slots 1 and 13. This would represent 180 electrical degrees and the sine of one-half of 180 degrees is 1, hence, the chord factor of the coil is 1, and the coil is 100 per cent. effective in generating a counter-electromotive force. Each slot equals $180 \div 12 = 15$ electrical degrees. Then if the coil lay in slots 1 and 11 it would span only 10 slots or $15 \times 10 = 150$ electrical degrees, and the chord factor would be the sine of one-half of 150 deg., or 75 deg., equals 0.96. This means that the winding is only 96 per cent. as effective in generating a counter-electromotive force in the latter case as it was in the former. If with full pitch, under a given condition, the winding was good for operation on 500 volts, then with the coils in slots 1 and 11 the winding would be good for only $500 \times 0.96 = 480$ volts.

Flame in Smoke-Stack of Locomotive-Type Boiler—What is the cause of smoke burning in the stack of a locomotive-type boiler? C. E. S.

In burning solid fuels, the appearance of flame in the stack, or issuing from it, usually is due to particles of burning fuel or heated ash carried by the draft from the furnace and swept through the tubes to be discharged as cinders or sparks. The appearance of combustion is more pronounced when the fire surfaces of the boiler need cleaning of soot, for then the temperature of the gases may remain high enough for the heated particles to continue to glow and present the appearance of burning as discharged from the stack. Flame, with appearance of gases burning at the outlet of a stack, may result from combustion of volatile gases liberated from the fuel by the heat of the furnace, but which have not been mixed with enough air for their combustion until reaching the very point of discharge to the atmosphere.

Capacity of Cylindrical Tanks—What is a short rule for computing the number of gallons contained by a cylindrical tank 72 in. in diameter by 18 ft. long, with flat heads; and what allowance should be made when the heads are bumped? W. R. J.

The cubical content in American gallons of the tank with flat heads is given by the computation:

$$\frac{(72 \times 72 \times 0.7854) \times (18 \times 12)}{231} =$$

$$(72)^2 \times 18 \text{ ft.} \times 0.0408 = 3{,}807.13 \text{ gal.}$$

that is, where d = diameter of the tank in inches and L = length in feet, the general formula for capacity of a cylindrical tank with flat heads would be given by the formula,

$$\textit{Gallons capacity} = d^2 \times L \times 0.0408$$

Where h = the height of a bumped head in inches and d = its diameter in inches, the volume of a bumped head is given in gallons by the expression:

$$\left[\left(\frac{h}{2} \times 0.7854\, d^2\right) + (h^3 \times 0.5236)\right] \div 231 =$$

$$\frac{h^3 \times 0.7854\, d^2}{2 \times 231} + (h^3 \times 0.00226).$$

Hence two bumped heads would contain the same number of gallons as a cylinder of diameter d and length h, $+ 2\,(h^3 \times 0.00226)$ gal., and the formula for complete capacity, including both bumped heads would be

$$\textit{Gallons capacity} =$$

$$\left(d^2 \times \textit{length of side in feet} + \frac{h}{12}\right) \times 0.0408 + 2(h^3 \times 0.00226)$$

Tanks for holding liquids under atmospheric pressure usually are provided with heads that are bumped so little that the value obtained for $2(h^3 \times 0.00226)$ is only a small percentage of the total tank capacity, and when there are two equal bumped heads the capacity is given close enough for most practical purposes by the formula

Number of gallons = dia. in in. × dia. in in. × length of side plus height of one head in feet × 0.0408.

[Correspondents should sign their communications giving full names and post office addresses.—Editor.]

when run without sufficient heat to more or less perfectly sion and large intake ports; (3) it was observed that the

Kerosene as a Fuel for High-Speed Engines*

By LAWRENCE SEATON

An account of tests run to obtain information regarding the correct design of a vaporizing system to successfully handle kerosene for high-speed engines. The description is given to the apparatus used, the method of making the tests, and the conclusions reached. Some consideration is also given to the question of the effect on the crank-case oil of unvaporized fuel leaking by the piston into the crank case.

AT THE present time there is a great deal of controversy regarding the correct design of a vaporizing system to successfully handle kerosene in high-speed engines. There has also been very little work done in determining the distribution of the heat in the fuel in such engines, and as to the effect on the crank-case oil due to unvaporized fuel passing by the piston and entering the crank case. It was therefore decided to fit up a high-speed engine so that the foregoing conditions could be carefully and accurately studied.

The apparatus used is shown in Fig. 1. The motor was a 4½ x 5½-in. high-speed heavy-duty type and was equipped with a Kingston carburetor connected to a specially designed vaporizer. The exhaust gases were piped directly to a calorimeter, but there was also provided a bypass pipe through the calorimeter, so that by means of dampers any desired amount of exhaust gas could be sent through the vaporizer and therefore any desired temperature maintained. Pyrometers were placed in the bypass and in the main-line exhaust pipe, and a thermometer was placed in the intake manifold. The air leading to the carburetor was maintained at a constant temperature by an electric heater. A manometer was connected to the intake opening into the carburetor.

Two Tabor engine indicators were used, one with a 240-lb. spring for measuring the combustion pressure and the other with an 80-lb. spring for measuring the compression pressure. A Dixie high-tension magneto was used for ignition. A water-spray nozzle was located in the intake manifold so that water might be introduced at high loads to prevent preignition.

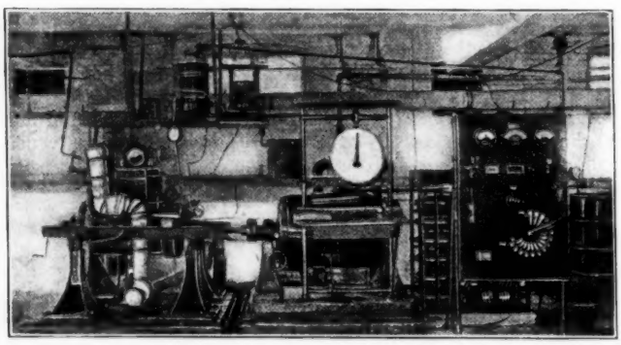


FIG. 1. APPARATUS USED IN CONDUCTING TESTS

The cooling water was weighed every fifteen minutes. The fuel was weighed on a specially designed scale connected with a beam-bell contact, which made accurate reading possible. The water used in the manifold to prevent preignition was weighed on a sensitive scale.

The calorimeter for exhaust gases consisted of a Wheeler surface condenser, the water passing through the tubes and the exhaust gas entering the shell. Since the moisture in the products of combustion was condensed, it was necessary to provide for draining this moisture from the bottom of the condenser. The water used in the calorimeter was weighed on a set of scales having a range of 0 to 12,000 lb. The load carried by the engine was maintained by means of a Sprague electric dynamometer. The load maintained was so constant that no governor was necessary on the engine, and it was possible to study its action under a constant throttle opening.

After bringing the engine up to a speed of 1100 r.p.m., the speed recommended by the makers, the load was put on the generator of the dynamometer and the reaction of the pole pieces measured through a series of calibrated beams to the dial on the dynamometer.

A series of tests was first run with the air entering the carburetor maintained at a constant temperature of 115 deg. F., and the temperature around the vaporizer was increased from an initial temperature of 150 deg. F. for the first test, by 100 deg. increments, until a temperature of 650 deg. F. was reached. This corresponds to a temperature of 785 deg. inside

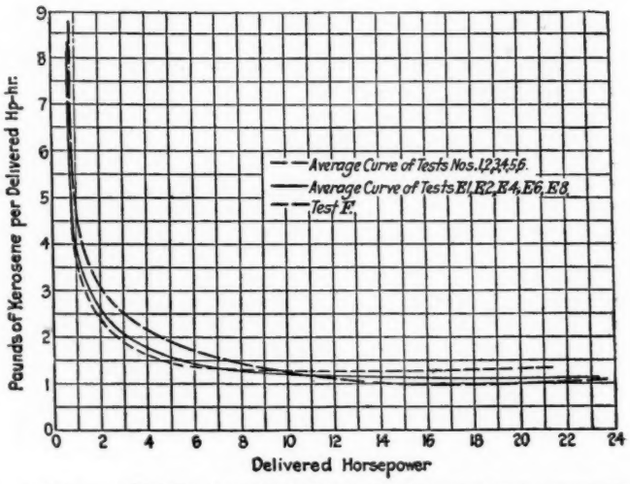


FIG. 2. CURVES OF DELIVERED HORSEPOWER VERSUS POUNDS OF FUEL

the vaporizers and, in order to obtain this condition, it was necessary to send all the exhaust gases through the vaporizer at low loads. The loads carried under this condition were approximately 5, 10, 15 and 20 hp. The length of test run on each load was two hours. These series of tests were known as tests Nos. 1 to 6.

Another series of tests was made while maintaining a constant temperature of 650 deg. on the pyrometer in the bypass around the vaporizers and increasing the temperature of the intake air by increments of 10 deg. The first test was run with an intake-air temperature of 125 deg. F. and was known as test No. E 1. Successive tests of this series were run and known as tests Nos. E 2, E 3, etc., and this process was continued until a maximum was obtained at which it was thought practicable to run the engine.

At the end of the series of "E" tests, which was thought to cover all conditions commonly met in practice, it was decided to run a test in which the limit of the apparatus was reached as far as furnishing heat to the mixture was concerned. This test was known as test F. All heat from the exhaust gases was passed through the vaporizer, and all possible current was passed through the heating coils in the air heaters. A so-called F test was run for each of the various loads, as was the case with the other series.

Indicator cards were taken at fifteen-minute intervals in order to ascertain the combustion pressure and to determine the evenness with which the fuel was burning in the cylinder, also to get some information as to the compression pressure. The indicator drum was not connected to the engine, but simply turned by hand while leaving the indicator cocks open.

The coil was cleaned out of the crank case at the end of each run, when its temperature, gravity and weight were determined. This was done to gain some definite information as to the effect of kerosene on the lubricating oil, especially

*Abstract of a paper presented at the annual meeting of the American Society of Mechanical Engineers, New York, Dec. 2 to 5, 1919.

A Perfected High-Pressure Rotary Compressor*

since it solves only one of the difficulties mentioned, it was valueless by itself.

when run without sufficient heat to more or less perfectly vaporize the fuel. From a summary of the results, the curve shown in Fig. 2 was plotted. This curve shows the weight of kerosene per horsepower per hour for the various horsepower outputs. It will be seen that the various heat changes made as described have practically no effect on the fuel consumption of the engine. It was observed, however, that the motor became much more flexible when the temperature of the ingoing air was raised. It was found that at low temperature the motor would not idle down below 800 or 900 r.p.m., while at the exceptionally high temperatures of the ingoing gases—about 375 deg. F.—it was found that the engine could be idled down to 150 r.p.m. and would pick up almost as well as when burning gasoline. It was also possible to start the engine on kerosene under these conditions.

The observation on the amount of kerosene deposited in the crank case was practically constant for all conditions, so that apparently the changes in heating the fuel had no effect in this matter. The only advantage apparent in heating the ingoing air and gas was that it made the motor more flexible.

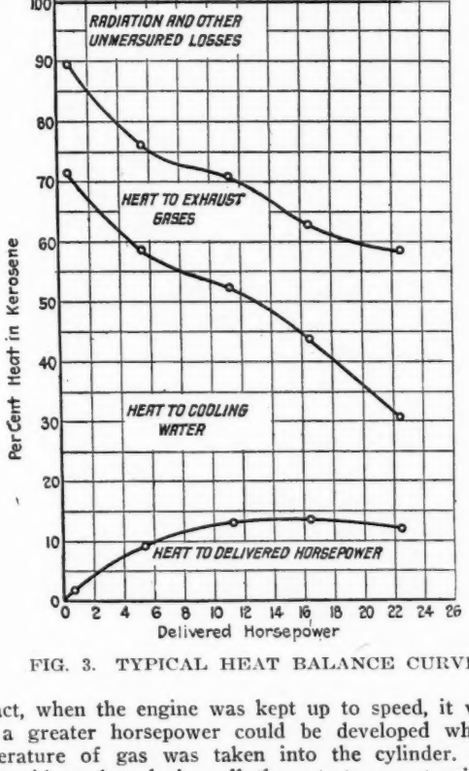


FIG. 3. TYPICAL HEAT BALANCE CURVES

In fact, when the engine was kept up to speed, it was found that a greater horsepower could be developed when a low temperature of gas was taken into the cylinder. It seems quite evident that during all these tests a wet mixture was taken into the cylinder, and that in no case was the kerosene thoroughly vaporized before entering.

The curve shown in Fig. 3 represents a typical heat distribution throughout the motor, and it will be observed that the maximum thermal efficiency is about 13 per cent. The percentage of heat going to the cooling water slightly decreases after the load increases, while the percentage of heat to the exhaust gases increases after the load increases. It will also be observed that the percentage of heat dissipated through radiation and other unmeasured losses, which includes the amount of fuel deposited in the crank case, increases as the load increases.

Some of the conclusions to be drawn from these tests are as follows: (1) It seems evident that to successfully burn kerosene in the type of internal-combustion engine now in general use, higher heat must be used so that the motor may be made sufficiently flexible to be practicable; (2) while the tests do not show the motor to be as efficient as when operating on gasoline, it is nevertheless believed that this defect can be overcome by designing the motor with high compression and large intake ports; (3) it was observed that the lubricating-oil temperature was higher when additional heat was added to the mixture, which means that a high flash-point oil would have to be used.

It is the belief of the writer that a motor designed as follows would handle kerosene at all loads successfully: The piston displacement should be greater per horsepower than that commonly used, a higher compression pressure should be obtained, the intake passages should be large and short, and the intake air should be heated to a temperature considerably above the boiling point of kerosene. This probably would be done with the exhaust gases, necessitating an automatic control at all loads.

New Engineering Publicity

One of the means that will be employed by the American Association of Engineers to promote engineering publicity throughout the United States is through a coöperative arrangement with the producer of several moving-picture weeklies. Arrangements have been made with the producers of six screen weeklies whereby the association will furnish lists of engineering projects and works, photographs of which will interest the public. After the film people have been notified of some engineering structure or event of sufficient interest, they will communicate with their correspondent living nearest the scene of the work or event, and he will either take still photographs or 100 or so feet of film, as the situation merits.

To make this project successful the association will require the active assistance of every professional engineer. Officials of corporations or construction companies who are doing or having done construction work or who are building or installing unusual or otherwise interesting machinery, engineers in charge of construction work or who are developing new methods or who know of spectacular or otherwise interesting features in which the public will be interested, can make this service a success by advising of such projects as will warrant photographing, the *Professional Engineer*, 63 E. Adams St., Chicago.

Do you know of any construction work, say of a large dam or bridge, or power plant or industrial works, or blast furnace, or cotton mill, which would be of sufficient interest to attract the attention of the general public? Do you know of a new process which has appealing scientific features and which can be photographed readily? Do you know of a survey which is to be attended by physical hardship or actual danger? Is there a building in your town which failed today because it was not designed or constructed under proper engineering supervision? Has your county or your state recently spent an enormous sum for highways? If it has, have the results been worthy of photographing? if you can answer any of these questions or any similar questions in the affirmative, send a postcard or brief letter or telegram advising the location of the work and give a brief description of its purpose with the approximate cost or other particular features which make it worth photographing. If the location is out of the usual course of travel, tell how the photographer can reach the work. The letter need not be long. Just outline the essentials as mentioned. Although the publicity committees of the chapters and clubs of the American Association of Engineers can be of great service in this matter, the foregoing appeal is not made wholly to the members of the American Association of Engineers. Engineers, public officials, corporation officials and others who are acquainted with engineering features of interest to the public are earnestly requested to render whatever assistance they are able in this development of engineering publicity.

Upset conditions in the coal industry in Great Britain are causing more and more interest in the substitution of oil fuel for coal, says the American Chamber of Commerce in London. It points out that the trend toward the use of oil fuel is well illustrated by the conversion of two of Britain's greatest liners to oil burners. Both the "Olympic," of the White Star Line, and the Cunarder "Aquitania" are being reconditioned and fitted with oil burners. Greater efficiency is expected and the engine-room personnel will be reduced perhaps from 350 to 40 or 50.

The field for this type of machine embraces every use possible for the reciprocating type and some that are not. It is

Boiler Explosion Kills Three

A Perfected High-Pressure Rotary Compressor*

By Chester B. Lord

The well-known disadvantages of a reciprocating machine have led to much research and many experiments in the hope of developing rotary machines both as prime movers and as pumps. In the compressor field three types have been developed—the centrifugal blower, the gear type and the eccentric rotor with a telescopic blade. The two former types are limited by practical considerations to low pressures, probably not over eight or ten pounds per single stage. The third type is capable of higher pressures, but up to the present has shown very low efficiencies.

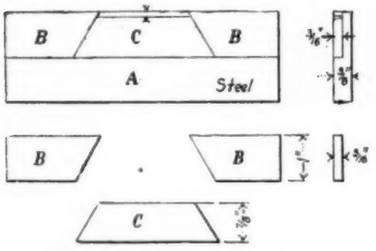


FIG. 1. DETAILS OF BLADE

The author describes, in this paper, an eccentric-rotor-and-telescopic-blade type compressor which has given 92 per cent. volumetric efficiency at 100 lb. pressure and which will pump a gas or liquid or a gas and liquid at the same time.

The main difficulties with this type of machine have been the necessity of maintaining a seal at one point between the rotor and the cylinder, the friction caused by the blade pressure against the end plates and the inner surface of the cylinder (the pressure being on one side of the blade, caused difficulty in moving it in and out of the slot in the rotor), and the difficulty of packing square corners.

The solution of the first difficulty has been accomplished by allowing the cylinder to rotate with the same surface speed as the rotor so that there is no sliding motion at the point of contact. In this machine the contact of the rotor with the cylinder carries the cylinder around, but since the circumference of the rotor is less than that of the cylinder, the angular velocity of the latter is less than that of the former. This principle is not original with the designer of this compressor, but since it solves only one of the difficulties mentioned, it was valueless by itself.

Excessive end pressure is overcome by floating end plates, held in contact with the cylinder by the pressure generated by the machine itself. These end plates, which are simply flat circular plates, are subject to the discharge pressure on the outside, and since the area of the outer surface is greater than the area of the inner surface, are held against the cylinder ends. These plates of course revolve with the cylinder or rotor or both, so there is little or no sliding to cause friction losses. The blade, moving in and out of its slot in the rotor, rubs against these floating cylinder ends, and this is the principal point of friction loss. From dimensions of a machine capable of compressing 100 cu.ft. of free air per minute, this total travel is calculated to be 93 ft. per minute, so the power lost is not great even for fairly high pressures.

The blade used is shown in Fig. 1. The blade proper is marked *A* and is cut away as shown. The pieces *B* and *C* are carried in the main blade, as shown. Centrifugal force throws the wedge-shaped piece *C* out, so pushing the packing pieces *B* against the ends of the cylinder and into the corners. The force with which these pieces press into the corners is regulated by the angle of the wedge sides. The main blade *A* has about $\frac{1}{32}$ in. clearance at each end.

For adjusting contact between the rotor and cylinder, a so-called wedge ring is used. This is simply an eccentric cradle carrying the bearings for the revolving cylinder and is turned by means of a threaded stud led through the outside casing.

Fig. 2 shows a section of a 20-ton refrigerating machine.

Among the advantages claimed for this machine is the possibility of direct-connecting it to the driver, as it can be run at any speed that is safe for the prime mover. Another advantage is its small space requirement as compared with reciprocating machines. As an example, a 100-ton rotary refrigerating machine requires only 60 sq.ft. floor space as against 1,200 sq.ft. for a horizontal reciprocating unit. The weights of the machines are given as eight pounds per ton capacity for the rotary machine and one hundred pounds per ton capacity for the reciprocating type.

The use of the floating cylinder ends, besides cutting down friction, enables the machine to handle liquids either alone or with gases. In a reciprocating compressor, if any liquid present cannot go out through the discharge valve fast enough, it simply breaks something. In this machine the end rings move away from the cylinder, allowing the liquid to escape, and as soon as the pressure is equalized, close up again.

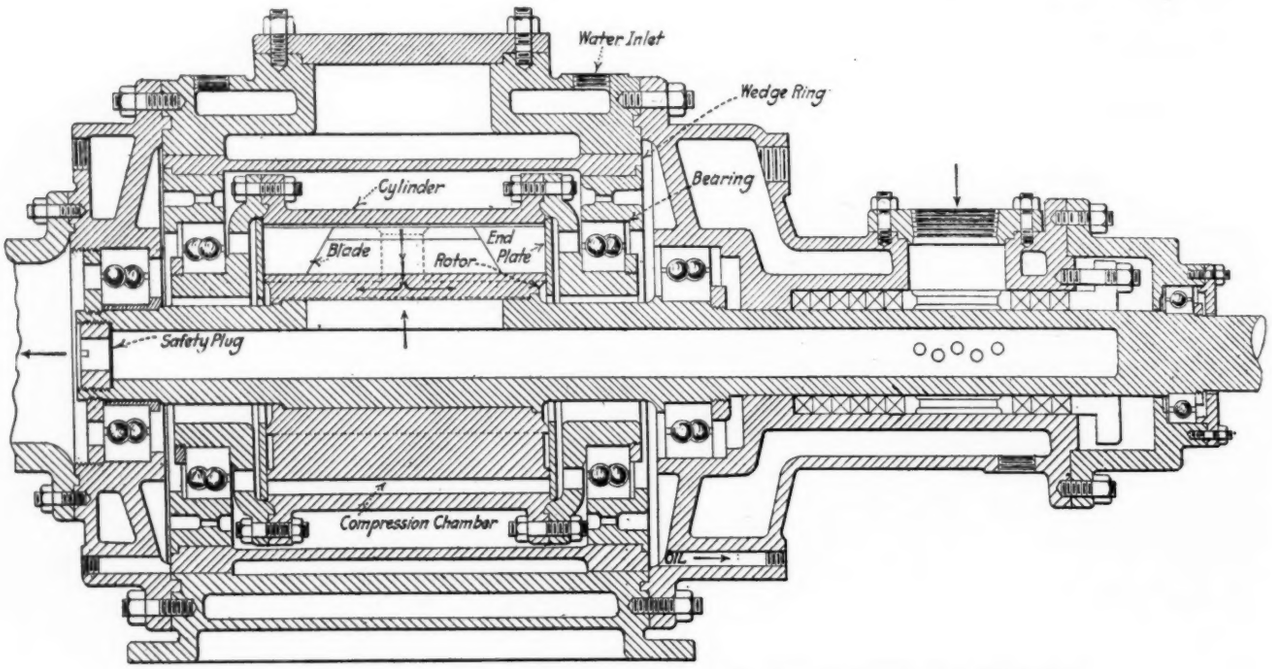


FIG. 2. CROSS-SECTION ASSEMBLY OF A 20-TON REFRIGERATING COMPRESSOR.

*Abstract of paper presented at the Annual Meeting American Society of Mechanical Engineers, Dec. 2-5, 1919.

THE COAL MARKET

New Construction

installed in same. Total estimated cost, $300,000. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

The field for this type of machine embraces every use possible for the reciprocating type and some that are not. It is possible to get 500 lb. pressure single-stage and 1000 lb. in three stages. It is possible to pull a 23½-in. vacuum against 180 lb. pressure. These conditions are not commercial requirements, but are given to indicate the machine's possibilities. It has been used as a blast-furnace blowing engine, as a 0.5 cu.ft. per minute refrigerating machine for household use and for street car compressors.

The author says that all the statements in the article have been demonstrated commercially, and hence it would seem that the long-looked-for rotary compressor has arrived.

Moisture in Insulation

In a paper, "The Story of Insulation," presented at the 12th annual convention of the Pennsylvania Electric Association, C. E. Skinner tells the following story regarding the amount of moisture in the insulation:

At the time of the construction of the Ontario Power Co.'s transmission plant at 60,000 volts, we had arrived at the stage of the art when we considered it advisable to thoroughly vacuum dry complete transformers before immersing them in oil. Equipment for this purpose was not available at the factory for transformers of the size used by the Ontario Power Co., and it was therefore decided to make the transformer tank itself the vacuum tank and provide means for vacuum drying of transformers after being placed in the tanks at the point of installation. After drying for a week or ten days, following the course of the drying by measuring insulation resistance of the transformers until this was considered satisfactory, oil was admitted to the first transformer while still under vacuum. As a final precaution a sample of oil was drawn from the bottom of the tank only to find that it was about 98 per cent. water. Investigation of a second transformer into which the oil had not been admitted, discovered 6 or 7 gallons of water in the bottom of the transformer tank, although the transformer itself was undoubtedly satisfactorily dried by the vacuum process. The water doubtless came partly from the transformer coils, partly from the laminated iron and partly from the air which was inevitably drawn into the transformer tank on account of the impossibility of making the tank absolutely vacuum-tight. This moisture, condensing on the cooler top and sides of the tank, collected at the bottom. The cure was simple and consisted in a double valve arrangement with a small tank between, allowing the condensed water to be drawn off as the drying proceeded. This incident shows the very large quantities of water which could be collected under the circumstances described and indicates that apparatus not satisfactorily protected by a moisture-proof coating or by immersion in oil requires special precautions in installation and starting. Later studies have indicated that moisture in extremely minute amounts may play a very important part in impairing insulation where the requirements are severe, as it may increase the dielectric losses and lower the insulation resistance and the dielectric value.

Canadian Engineers Will Meet in Montreal

The annual business and professional meeting of the Engineering Institute of Canada will be held at the Institute quarters, Mansfield street, on Jan. 27, 28 and 29.

At this annual convention questions of interest to the engineering profession of Canada will be discussed as well as topics of special interest to the people of the province of Quebec.

Papers dealing with the commercial, industrial and financial problems of the province will be delivered, also on its water-powers, both developed and undeveloped, its highways, its forest products and a general survey of its commercial potentialities.

It is expected that the convention will be the largest and most representative that has ever been held and it is hoped that it may assist in giving the public a more comprehensive view of the essential work achieved by the members of the engineering profession in building up the prosperity of Canada.

A bill has passed the Oregon Legislature adopting the A. S. M. E. Boiler Code, and now awaits the signature of the governor of the state. The Seattle boiler rules are about to be amended, making the code apply to that city.

Boiler Explosion Kills Three

At the East Chicago works of the Interstate Iron and Steel Co., a 250-hp. vertical water-tube boiler exploded at 4:30 a. m. on the morning of Jan. 19. Three men were killed outright, twelve were injured more or less seriously, but none fatally. The property damage was estimated at $10,000. The boiler was one of three in an auxiliary battery that was used to supply the demand for steam in excess of that furnished by the waste-heat boilers which ordinarily carried the bulk of the load.

The boilers were equipped with hand-fired dutch-oven furnaces. Two of them were being fired up on the morning of the accident, preparatory for the morning shift which started at 6 a. m. Before the working pressure of 120 lb. gage had been reached, one of the boilers let go. The tubes, accompanied by the bottom tube sheet, rose with the top drum and descended some 700 ft. away from the initial location. The settings of the other two boilers and the boiler house were demolished.

Closed valves proved that the boilers had not been cut in on the line. Apparently the cause of the accident was a hidden defect, which at the time of writing had not been detected. The boiler had been inspected and reported in good condition by an insurance inspector just twelve hours before the accident. More complete details will be given in a later issue.

California Requires More Hydro-Electric Power

"More hydro-electric energy must be developed in California to meet the present requirements, and vastly more is necessary to accommodate future demands."

There are eighty-four electric utilities in the state of California, operating seventy-five hydro-electric plants, with an installed capacity of 465,000 kw., and 50 steam plants with an installed capacity of 305,000 kw., making a total of 125 plants, aggregating 770,000 kilowatts, says a newspaper report.

During the year 1918 these plants generated a total of 2,892,000,000 kw.-hr., of which 2,163,000,000 kw.-hr., or 75 per cent. of the total, were produced from water power.

This power is transmitted through 7,300 miles of high-tension transmission lines to points of distribution, from which 84,000 miles of secondary distribution lines extend. Electric service is supplied to 545,000 consumers.

The installed capacity of consumers' lights, motors and other power-consuming devices exceeds 1,800,000 horsepower. Nearly 900,000 kw. of distribution transformers are installed on these systems.

A. A. E. Claims Membership of 18,000

The results of the membership drive held during December by the American Association of Engineers have been tabulated, and notwithstanding the difficulties imposed by the coal strike, indications are that the total number of members will approximate 18,000. At the close of business on Dec. 31, the number of fully accredited members exceeded 10,400. About 3,000 additional members have been accepted, but were taking the time alloted to pay dues, and most of the 7,000 applications received during the month of December had not been acted upon. Allowing for contingencies, the net membership should approach closely the total figure previously given.

CORRECTION: Through an error the review for the year, under Power Plant Legislation, in the issue of Jan. 6, included Massachusetts among those states which had adopted the A. S. M. E. Boiler Code. Also, the map on page 62 of the Jan. 13 issue likewise included this state. As is well known, the state of Massachusetts has its own boiler code, which very closely resembles the A. S. M. E. Code, but is not identical, and the latter code has not been officially adopted as yet by the state of Massachusetts.

Through Stone & Webster, of Boston, the Hartford Electric Light Co. has arranged for the purchase of the Connecticut Power Co., operating a large hydro-electric power plant on the Housatonic River and in western Connecticut.

Penn., Bethlehem—The Lehigh Alumni **Mich., St. Ignace**—Cunning & Mulcrone a 3 story, 59 x 81 ft. school. Estimated

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$8.20@$8.65
Stove	8.45@ 9.05
Chestnut	8.55@ 9.05
Pea	7.05@ 7.40
Buckwheat	3.60@ 3.80
Rice	2.30@ 2.50
Barley	1.25

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.85@$3.35	$3.15@$3.60
F.o.b. Philadelphia, gross tons	5.05@ 5.60	5.35@ 5.90
F.o.b. New York, gross tons	5.40@ 5.95	5.75@ 6.25
Alongside Boston (water coal), gross tons	7.00@ 7.75	7.60@ 8.00

Pocahontas and New River are practically off the market for coastwise shipment, but are quoted at $6.25@$7.00.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports are as follows:

Anthracite

	Company Coal
Broken	$7.80@$8.25
Egg	8.20@ 8.65
Stove	8.45@ 9.05
Chestnut	8.55@ 9.05
Pea	7.05@ 7.40
Buckwheat	5.15
Rice	4.50
Barley	4.85
Boiler	4.85

Bituminous

Government prices at mines:	Spot
South Fork (best)	$3.25@$3.50
Cambria (best)	3.00@ 3.25
Cambria (ordinary)	2.60@ 2.90
Clearfield (best)	3.00@ 3.25
Clearfield (ordinary)	2.60@ 2.90
Reynoldsville	2.85@ 2.90
Quemahoning	3.25@ 3.50
Somerset (medium)	3.00@ 3.25
Somerset (poor)	2.50@ 2.75
Western Maryland	2.50@ 2.75
Fairmont	2.25@ 2.50
Latrobe	2.60@ 2.90
Greensburg	2.75@ 3.00
Westmoreland ¾ in.	3.40@ 3.50
Westmoreland run-of-mine	2.75@ 3.00

PHILADELPHIA—Anthracite prices are practically the same as those listed above for New York. Bituminous coal prices vary according to district from which they are mined. For ordinary slack the price is $2.45@$2.55; lump, $3.00@$3.35, at the mines.

BUFFALO—

Anthracite

	On Cars, Gross Ton	At Curb, Net Ton
Grate	$8.55	$10.80
Egg	8.80	10.65
Stove	9.00	10.85
Chestnut	9.10	10.85
Pea	7.75	9.30
Buckwheat	5.70	7.75

Bituminous

Allegheny Valley	$4.80
Pittsburgh	4.65
No. 8 Lump	4.65
Mine Run	4.80
Slack	4.10
Smokeless	4.60
Pennsylvania Smithing	5.70

CLEVELAND—Prices of coal per net ton delivered in Cleveland are:

Anthracite

Egg	$12.25@$12.40
Chestnut	12.50@ 12.70
Grate	12.25@ 12.40
Stove	12.40@ 12.60

Pocahontas

Mine-run	$7.50

Domestic Bituminous

West Virginia split	$8.50
No. 8 Pittsburgh	$6.60@ 6.90
Massillon lump	8.25@ 8.50
Coshocton lump	7.15

Steam Coal

No. 6 slack	$5.25@$5.50
No. 8 slack	5.10@ 5.50
Youghiogheny slack	5.25@ 5.50
No. 8 ¾ in.	5.70@ 6.00
No. 6 mine-run	5.25@ 5.50
No. 8 mine-run	5.75

Only coal available is mine-run Pocahontas.

MIDDLE WEST—Chicago quotations, F.o.b. cars at mine:

	Springfield, Carterville, Williamson, Franklin, Saline, Harrisburg	Fulton, Peoria	Grundy, La Salle, Bureau, Will
Lump	$2.55@$2.70	$2.95@$3.10	$3.25@$3.40
Washed	2.75@ 2.90	.....	3.45@ 3.60
Mine run	2.35@ 2.50	2.75@ 2.90	3.00@ 3.15
Screenings	2.05@ 2.20	2.35@ 2.50	2.75@ 2.90

New Construction

PROPOSED WORK

Me., Augusta—Lockwood, Green & Co., Engrs., 60 Federal St., Boston, Mass., will receive bids for the construction of a 6 story, 65 x 135 ft. storehouse on Water St., for the Edwards Mfg. Co., Water St. A steam heating system will be installed in same. Total estimated cost, $100,000.

Vt., Lunenburg—The Fitzdale Paper Mills are having preliminary plans prepared for the construction of a 1 story power house. A steam heating system will be installed in same. Total estimated cost, $1,000,000. George F. Hardy, 309 Bway., New York City, Archt. and Engr.

Mass., Boston—John H. Lyons, 15 State St., is preparing plans for the construction of a 5 story, 35 x 110 ft. mercantile building on Stanhope St. A steam heating system will be installed in same. F. A. Norcross, 46 Cornhill St., Archt.

Mass., Wellesley—F. J. Untersee, Archt., 585 Boylston St., Boston, will soon award the contract for the construction of a 4 story, 110 x 190 ft. college building and tower on Worcester St., for the Academy of the Assumption, Wellesley Hills. A steam heating system will be installed in same.

Conn., Meriden—The Griswold, Richmond & Block Co., 2 West Main St., is having plans prepared for the construction of a 2 story, 120 x 150 ft. business building on West Main and South Grove Sts. A steam heating system will be installed in same. Total estimated cost, $100,000. David Bloomfield, 129 State St., Archt.

Conn., New Haven—Alexander & Links, 138 State St., plans to remodel the present 4 story building on State St., into an ice plant for its own use.

N. Y., Brooklyn—Lockwood, Green & Co., Archts. and Engrs., 101 Park Ave., New York City, will receive bids until Jan. 23 for the construction of a 3 story, 175 x 200 ft. factory on 51st and 52nd Sts. and 2nd Ave., for Bemis Bros. Bag Co. A steam heating system will be installed in same. Total estimated cost, $500,000.

N. Y., Brooklyn—Shampan & Shampan, Archts. and Engrs., 50 Court St., are having plans prepared for the construction of a 4 story, 40 x 100 ft. laundry at 835-849 Myrtle Ave. A steam heating system will be installed in same. Total estimated cost, $150,000. Owner's name withheld.

N. Y., Brooklyn—The Y. M. H. A., 63 Morton St., plans to build a 4 story, 100 x 150 ft. building on B'way and Rodney St. A steam heating system will be installed in same. Total estimated cost, $300,000. H. J. Rosenson, Pres.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York City, plans to build a 5 story school on Nostrand Ave. and Sandford St., cost, $400,000; 3 story school on East 92nd St. and Ave. L., Canarsie, $200,000; 5 story school on 70th St. and 18th Ave., $400,000; 5 story school on 62nd St. and Ft. Hamilton Ave., $400,000; 4 story school on Newport St. and Stone Ave., $450,000; 5 story school on Saratoga and Livonia Aves., $450,000; 5 story school on New York and Tilden Aves., $500,000; 4 story addition to P. S. 16, Wilson St., near Bedford Ave., $400,000; 4 story addition to P. S. 136, 4th Ave. and 31st St., $400,000; 4 story addition to P. S. 67, $350,000; 4 story school on 86th St. and 2nd Ave., 350,000. Steam heating systems will be installed in same. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., Far Rockaway—The Bd. Educ., 500 Park Ave., New York City, is having plans prepared for the construction of a school addition, here. A steam heating system will be installed in same. Total estimated cost, $200,000. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., Jamaica—The Bd. Educ., 500 Park Ave., New York City, plans to build a 4 story school on Liberty, Bryant and Jerome Aves. A steam heating system will be installed in same. Total estimated cost, $400,000. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., Long Island City—The Bd. Educ., 500 Park Ave., New York City, plans to build a 3 story school on Pierce Ave. and Briell St. A steam heating system will be installed in same. Total estimated cost, $300,000. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., Maspeth—The Bd. Educ., 500 Park Ave., New York City, plans to build a 2 story addition to P. S. 72 on Maspeth Ave. A steam heating system will be installed in same. Total estimated cost, $150,000. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., Rockaway Beach (Far Rockaway P. O.)—The Bd. Educ., 500 Park Ave., New York City, is having plans prepared for the construction of a school addition at Rockaway Beach. A steam heating system will be installed in same. Total estimated cost, $300,000. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., New York—The Bd. Educ., 500 Park Ave., is having plans prepared for the construction of a 5 story, 60 x 193 ft. school on Fox St. and Leggett Ave. (Bronx Boro). A steam heating system will be installed in same. Total estimated cost, $250,000. C. B. J. Snyder, Municipal Bldg., Archt. and Engr.

N. Y., New York—S. Finkelstein, c/o W. Koppe, Archt. and Engr., 935 Intervale Ave. (Bronx Boro), will build a 6 story, 90 x 100 ft. clothing factory on Leggett and Whitlock Aves. A steam heating system will be installed in same. Total estimated cost, $170,000. Work will be done by day labor.

N. Y., New York—L. Gold, 44 Court St., plans to build a garage on 55th St. and 10th Ave. A steam heating system will be installed in same. Total estimated cost, $100,000. Work will be done by day labor.

N. Y., New York—The Gotham National Bank, 1819 Bway., will build a 22 story, 85 x 100 ft. bank and office building at 303 West 59th St. A steam heating system will be installed in same. Total estimated cost, $3,000,000. Work will be done by day labor.

N. Y., New York—The New York Curb Market Assn., Wall St., plans to build a court exchange building on Trinity Pl. and Greenwich St. A steam heating system will be installed in same. Total estimated cost, $700,000. Starrett & Van Vleck, 8 West 40th St., Archts. and Engrs.

N. Y., New York—The Allerton House Corp., 143 East 39th St., is having plans prepared for the construction of a 14 story hotel on Lexington Ave. and 57th St. A steam heating system will be installed in same. Total estimated cost, $1,500,000. A. L. Harmon, 3 West 29th St., Archt. and Engr.

N. Y., New York—The Corn Exch. Bank, 13 William St., is having plans prepared for the construction of a 3 story, 50 x 100 ft. bank, office and store building at 525-527 B'way. A steam heating system will be installed in same. Total estimated cost, $175,000.

N. Y., New York—Shampan & Shampan, Archts. and Engrs., 50 Court St., Brooklyn, are in the market for a 350 hp. steam power boiler, generators and motors for the proposed new laundry and manufacturing building on Myrtle and Marcy Aves., Brooklyn.

N. Y., White Plains—The Bd. Educ. is having preliminary plans prepared for the construction of a high school. A steam heating system will be installed in same. Total estimated cost, $125,000. Tooker & Marsh, 101 Park Ave., New York City, Archts. and Engrs.

N. J., Jersey City—The Standard Theatre Co., c/o E. C. Horn Sons, Archts. and Engrs., 1476 B'way, New York City, will soon award the contract for the construction of a theatre on Central Ave. and Sherman Pl. A steam heating system will be installed in same. Total estimated cost, $250,000.

N. J., Hoboken—The White Metal Mfg. Co., 1006 Clinton Ave., is having plans prepared for the construction of a 6 story, 135 x 125 ft. factory and a 2 story, 20 x 80 ft. foundry. A steam heating system will be installed in same. J. C. Schaffler & Co., 38 West 32nd St., New York City, Archt. and Engr.

N. J., Trenton—H. R. Mallinson Co., Inc., 136 Madison Ave., New York City, plans to construct a 1 story, 50x 70 ft. power house on Parker Ave. Estimated cost, $15,000.

Penn., Bethlehem—The Lehigh Alumni Association, Lehigh University, is having plans prepared for the construction of a 2 story, 80 x 160 ft. memorial building. A steam heating system will be installed in same. Total estimated cost, $350,000. T. Visscher & J. Burley, 363 Lexington Ave., New York City, Archts. and Engrs.

Penn., Chester—The Cochrane Estate plans to build an 18 story office building. A steam heating system will be installed in same. Total estimated cost, $450,000. E. W. Brazer, 1133 Bway., New York City, Archt. and Engr.

Penn., Easton—The McCormick Co., Archt. and Engr., 41 Park Row, New York City, is having plans prepared for the construction of a bakery plant. A steam heating system will be installed in same. Total estimated cost, $100,000. Owner's name withheld.

Penn., Lewistown—The Viscose Co., Marcus Hook, plans to build a plant, consisting of 5 buildings for factory purposes, also a number of houses for employes. A steam heating system will be installed in same. Total estimated cost, $2,000,000. Ballinger & Perrot, 17th and Arch Sts, Philadelphia, Archt. and Engr.

Penn., Philadelphia—The city is having plans prepared for the construction of a 2 story, 200 x 330 ft. library at 19th, 20th, Vine and Wood Sts. A steam heating system will be installed in same. Total estimated cost, $3,000,000. Horace Trumbaner, Land Title Bldg., Archt. and Engr.

Penn., Scranton—The city plans to build a 2 story, 80 x 80 ft. school on Van Buren St. A steam heating system will be installed in same. Total estimated cost, $115,400.

Penn., Scranton—The city plans to build a 3 story, 120 x 150 ft. school on Madison St. A steam heating system will be installed in same. Total estimated cost, $402,300.

Penn., Scranton—The city plans to build a 3 story, 100 x 115 ft. school on Providence Rd. A steam heating system will be installed in same. Total estimated cost, $277,350.

Penn., Scranton—Mark K. Edgar, Bd. of Trade Bldg., plans to build a 6 story, 140 x 320 ft. incubator plant on Lock Ave. A steam heating system will be installed in same. Total estimated cost, $1,000,000.

Del., Wilmington—The White Automobile Co., East 79th St. and St. Clair Ave., Cleveland, O., has had plans prepared for the construction of a 2 story sales room and garage on 31st St. and Market Ave. A steam heating system will be installed in same. Total estimated cost, $100,000. Watson Eng. Co., Hippodrome Bldg., Cleveland, O., Engr.

Va., Norfolk—The Third Christian Church is having plans prepared for the construction of a 1 story, 86 by 127 ft. church on Llewelly Ave. A steam heating system will be installed in same. Total estimated cost, $100,000. W. H. Nicklas, 1900 Euclid Bldg., Cleveland, O., Archt.

N. C., Lexington—The city will receive bids until Jan. 20 for the construction of a pumping station and a 500,000 gal. storage reservoir, also for the installation of motor driven centrifugal pumps, etc. G. C. White, Durham, Engr.

Miss., Jackson—The city will receive bids about Feb. 15 for the construction of three 2 story school buildings. A low pressure steam heating system will be installed in same. Total estimated cost, $200,000. E. L. Bailey, Secy. Emmett J. Hull, Jackson, Archt.

O., Canton—Edward L. Smith, c/o Charles Firestone, Archt., Renkert Bldg., will receive bids until Feb. 2 for the construction of an 8 story hotel. A steam heating system will be installed in same. Total estimated cost, $400,000.

O., West Barberton—The Portage Rubber Co. is having plans prepared for the construction of a plant, including an office building and power house. Total estimated cost, $200,000.

Mich., Allegan—The Bd. Educ. plans to build a 3 story, 100 x 158 ft. high school. A steam heating system will be installed in same. Total estimated cost, $150,000. John D. Chubb, 109 North Dearborn St., Chicago, Archt.

Mich., St. Ignace—Cunning & Mulcrone plan to build a 3 story, 70 x 136 ft. hotel here. A steam heating system will be installed in same. Total estimated cost, $130,000. F. E. Parmelee, Iron Mountain, Archt.

Mich., Strathmoor—School Dist. No. 4, Wayne Co., c/o Horace H. Hart, will soon award the contract for the construction of a 2 story, 90 x 110 ft. school. A steam heating system will be installed in same. Total estimated cost, $125,000. W. H. Adams, Vinton Bldg., Detroit, Engr. Butterfield & Butterfield, 1113 David Whitney Bldg., Detroit, Archt.

Ill., Chicago—A. S. Alschuler, Archt., 28 East Jackson Blvd., will soon award the contract for the construction of a 3 story, 200 x 400 ft. auto sales and service building on Michigan Ave., near 22nd St., for the Hudson Motor Co., 1615 South Michigan Ave. A steam heating system will be installed in same. Total estimated cost, $300,000.

Ill., Chicago—The Bd. Educ., 7 South Dearborn St., will soon award the contract for the construction of a 3 story, 132 x 175 ft. grade school on Augusta St., near Laramie Ave. A steam heating system will be installed in same. Total estimated cost, $350,000. John Howatt, 7 South Dearborn St., Archt. A. F. Hussander, 7 South Dearborn St., Engr.

Ill., Chicago—The University of Chicago is having plans prepared for the construction of a 100 x 100 ft. chapel. A steam heating system will be installed in same. Total estimated cost, $1,500,000. B. Goodhue, 2 West 47th St., New York City, Archt. and Engr.

Wis., Milwaukee—The City Sewerage Comm. has retained W. J. Sands, Consult. Eng., 1338 Wells Bldg., to prepare plans for furnishing of power plant equipment for the proposed power plant on Jones Island; not decided whether coal burning, steam boilers, oil burning or internal combustion engine type. Total estimated cost, $850,000 to $1,700,000.

Wis., Milwaukee—H. W. Voelz, Archt. and Engr., 86 Michigan St., is preparing plans for the construction of a 2 story, 70 x 115 ft. dairy. A refrigeration system will be installed in same. Total estimated cost, $75,000. Owner's name withheld.

Wis., Racine—Louis Lehle, Archt., 3810 B'way, Chicago, will soon award the contract for the construction of a 4 story, 100 x 225 ft. warehouse for the Horlicks Malted Milk Co., Horlicksville St. A steam heating system will be installed in same. Total estimated cost, $300,000.

Wis., Sheboygan—The Standard Oil Co., Wells St., Milwaukee, has had plans prepared for the construction of two 2 story, 60 x 95 ft. filling stations and office building on Calumet Rd. and 15th St. Electric pumps, etc., will be installed in same.

Wis., Stevens Point—The Citizens' Natl. Bank will receive bids for the construction of a 1 story, 25 x 100 ft. bank. A steam heating and refrigerating system will be installed in same. Total estimated cost, $125,000. A. Moorman & Co., Chamber of Commerce Building, Minneapolis, Minn., Archt.

Wis., Tomahawk—The city has had plans prepared for the installation of 2 centrifugal pumps, capacities of 150 and 500 gal. per min.

Wis., Two Rivers—The Bd. Educ. is having preliminary plans prepared for the construction of a high school. A steam heating system will be installed in same. Total estimated cost, $200,000. John D. Chubb, 109 North Dearborn St., Chicago, Ill., Archt.

Ia., Cherokee—The State Bd. of Control, Des Moines, is having plans prepared for the construction of a pipe line, pumphouse and reservoir, also for furnishing pumping equipment in connection with the proposed waterworks improvements here. Total estimated cost, $70,000. W. E. Buell, Davidson Bldg., Sioux City, Engr.

Ia., Washta—The city will receive bids until Feb. 15 for the construction of a well, pumphouse, reservoir and distribution system in connection with the proposed waterworks improvements. Total estimated cost, $22,000. G. S. Strivers, Clk. W. E. Buell, Sioux City, Engr.

Ia., Woodbine—The Bd. Educ. will soon award the contract for the construction of a 3 story, 59 x 81 ft. school. Estimated cost, $100,000. Steam heating contract will be sub-let. E. E. Higgins, Secy. W. E. Hulse & Co., 210 Masonic Temple, Des Moines, Archt.

Minn., Minneapolis—The Bd. Educ. will soon award the contract for the construction of a 3 story, 61 x 163 ft. addition to the Calhoun School on Girard Ave. A low pressure steam heating system will be installed in same. Total estimated cost, $200,000.

Kan., Hugoton—The city will receive bids until Jan. 30 for the construction of a water system and electric light plant. Estimated cost, $60,000. R. L. Smith, Chn. Ruckel Eng. Co., Hutchinson, Engr. Noted Sept. 30.

Kan., Neodesha.—The Standard Oil Co. of Kansas, 5301 East 9th St., Kansas City, plans to construct a 1 story refinery. Project includes 42 additional stills, a modern boilerhouse that will develop 5000 hp., tanks with a capacity of 300,000 bbls. of oil, etc. Total estimated cost, $1,500,000.

S. D., Ispwich—The Bd. Educ. is having plans prepared for the construction of a 2 story, 75 x 126 ft. grade and high school. Steam heating and fan ventilation systems will be installed in same. Total estimated cost, $100,000. Edwins & Edwins, 911 Northwestern Bank Bldg., Minneapolis, Engrs.

Okla., Mangum—Hawk & Parr, Archts., 501 Security Bldg., Oklahoma City, are preparing plans for the construction of a 3 story, 100 x 175 ft. high school on Main St., for the city. A steam heating system will be installed in same. Total estimated cost, $130,000.

Okla., Norman—The city voted $125,000 bonds to construct an electric light and power plant.

Okla., Oilton—The city voted $40,000 bonds to construct 2 wells and install air lift system in the pumping station.

Wash., Puget Sound—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., will receive bids until Feb. 11 for an extension to the central power plant here.

Cal., Pasadena—The Water Dept. will soon lay main to the Annandale Dist., at a cost of about $125,000, install booster pump, about $10,000, also build concrete and earth dam to cost $15,000. Work will be done by day labor. S. B. Morris, City Hall, Engr.

Tex., Dallas—A. C. Bossom, Archt. and Eng., 366 5th Ave., New York City, will soon award the contract for the construction of a 10 story office building, for the Magnolia Petroleum Co., Great Southwestern Life Bldg. A steam heating system will be installed in same. Total estimated cost, $1,000,000.

Tex., Dallas—Lowe's Enterprises, 1492 B'way., New York City, are having plans prepared for the construction of a theatre. A steam heating system will be installed in same. Total estimated cost, $300,000. T. W. Lamb, 644 8th Ave., New York City, Archt.

Okla., Pryor Creek—V. V. Long & Co., Consult. Engr., 1300 Colcord Bldg., Oklahoma City, is preparing preliminary plans for the construction of a pumping station, transmission line, etc., for the city.

Col., Yuma—The Town Council will soon award the contract for the construction of a steam electric light power plant. Estimated cost, $50,000. R. D. Salisbury, 1415 East Colfax Ave., Denver, Engr.

Wash., Yakima—The Board of Directors of Yakima Co. Agricultural Union plans to build a 2 or 3 story addition to the cold storage plant on North 1st St. The Union has authorized $150,000 bond issue to cover the cost of same.

Cal., Newport Beach—The Newport Heights Irrigation Dist. is preparing plans for the construction of a pumping plant, mains, reservoirs and distributing system. Total estimated cost, $160,000. P. E. Kressly, Engr.

Cal., San Jose—The Bayside Canning Co., Alnso St., is having plans prepared for the construction of a 1 story cold storage plant. Estimated cost, $70,000. C. S. McKenzie, Bank of San Jose Bldg., Archt.

Ont., Newmarket—The city is having plans prepared for the construction of

sewers on Darcy and Yonge Sts., including an outfall sewer, disposal and an activated sludge plant, pumphouse and electrically driven compressed air pumps. Total estimated cost, $60,000. E. A. James Co., Ltd., 36 Toronto St., Toronto, Engr.

Ont., Owen Sound—The Bd. Educ. plans to build a 3 story Collegiate Institute. A vacuum steam heating system will be installed in same. Ratepayers will vote on $180,000 by-law in January to raise money to cover cost of same.

Ont., Toronto—The Auto Service Co., 139 Pears Ave., is having plans prepared for the construction of a 6 story garage on Richmond St. A vacuum steam heating system will be installed in same. Total estimated cost, $600,000. Banigan & Thompson, 7 King St., E., Engrs.

Ont., Toronto—The Board of Governors of the University of Toronto, Queens Park, plans to build six 2 and 3 story buildings, including an addition to the central heating plant. Total estimated cost, $2,000,000. Dailing & Pierson, 2 Leader Lane, Archts.

Ont., Toronto—T. L. Church, Chn. of Bd. of Control, City Hall, will receive bids until Feb. 10 for the supply and installation of one or more 16 to 20,000,000 gal. centrifugal pumps at the waterworks mains pumping station. Estimated cost, $75,000. R. C. Harris, City Engr.

Ont., Windsor—The Borroughs Adding Machine Co., 10 Chatham St., E., has engaged Albert Kahn, Archt., Marquette Bldg., Detroit, Mich., to prepare plans for the construction of an adding machine factory. A steam heating system will be installed in same. Total estimated cost. $250,000.

Ont., Woodstock—The De Long Hook & Eye Co., 41 Finkle St., plans to alter an existing 3 story building and convert same into a factory. A steam heating system, electric motors and generators for light and power will be installed in same.

Alta., Calgary—The Dept. Pub. Wks., Capitol, Ottawa, Ont., will receive bids until Feb. 5 for the construction of an 11 story, 154 x 160 ft. public building on 1st St., E. Three tubular boilers and automatic stokers, sprinkler type, will be installed in same. Total estimated cost, $400,000.

Alta., Edmonton—The Marshall-Wells Co., Lake Ave., S., Duluth, and German & Jenssen, Archts. and Engrs., Exch. Bldg., Duluth, will receive bids until March 1 at the Lindsay Bldg., Winnipeg, Man., for the construction of a 3 story, 100 x 150 ft. warehouse and office building here. A steam heating system will be installed in same. Total estimated cost, $375,000.

B. C., Vancouver—T. W. Lamb, Archt., 644 8th Ave., New York City, is preparing plans for the construction of a theater. A steam heating system will be installed in same. Total estimated cost, $300,000. Owner's name withheld.

CONTRACTS AWARDED

N. Y., Long Island City—The Standard Steel Co., 1920 Bway., New York City, has awarded the contract for the construction of a 4 story service station on South James St., from William to Ely Aves., to L. Gold, 44 Court St., Brooklyn. A steam heating system will be installed in same. Total estimated cost, $150,000.

N. Y., New York—S. Weil, 194 Franklin St., has awarded the contract for the construction of a 9 story, 60 x 100 ft. store and loft building at 502-508 Canal St., to J. H. Taylor Construction Co., 110 West 40th St. A steam heating system will be installed in same.

N. Y., Troy—The state has awarded the contract for the construction of a 2 story, 183 x 256 ft. armory on 15th St., to Peter Keeler, 425 Orange St., Albany, at $379,140. Heating contract will be sub-let.

N. J., Atlantic City—The Atlantic National Bank, Atlantic and Penn Aves., has awarded the contract for alterations and additions to the present bank building, to Hoggson Bros., 485 5th Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $200,000.

N. J., Atlantic City—The Holy Spirit Roman Catholic Church has awarded the contract for the construction of a 2 story, 80 x 138 ft. school, to Michael Melody & Son, 1645 North Broad St., Philadelphia. A steam heating system will be installed in same. Total estimated cost, $175,000.

Penn., Philadelphia—The Misericodia Hospital, 54th St. and Cedar Ave., will build a 6 story, 44 x 112 ft. building. A steam heating system will be installed in same. Total estimated cost, $300,000. Work will be done by day labor.

Penn., Philadelphia—The Neel-Cadillac Co., c/o Ballinger & Perrot, Archts., 17th and Arch Sts., has awarded the contract for the construction of a 7 story, 150 x 330 ft. vice building at 25th St. and Penn, Olive and Fairmont Aves., to Ballinger & Perrot, 17th and Arch Sts. A steam heating system will be installed in same. Total estimated cost, $1,000,000.

Penn., Pottstown—The Hill School has awarded the contract for the construction of a 2 story, 48 x 120 ft. memorial hall and library on High and Madison Sts., to W. E. Hale, 1636 Ludlow St., Philadelphia. A steam heating system will be installed in same. Total estimated cost, $100,000.

Penn., Steelton—The Peoples Bank will build a 1 story, 36 x 80 ft. building on Front and Locust Sts. A steam heating system will be installed in same. Total estimated cost, $100,000. Work will be done by day labor.

Md., Baltimore—The Fidelity Storage Co., 812 Equitable Bldg., has awarded the contract for the construction of a 6 story, 50 x 125 ft. warehouse at 2104-08 Maryland Ave., to the West Construction Co., 907 American Bldg. Contract for installing heating system will be sub-let. Total estimated cost, about $200,000.

O., Canton—The Pythian Castle Building Co., has awarded the contract for the construction of a 7 story, 75 x 115 ft. hotel and lodge building, to the Drummond-Miller Co., 4500 Euclid Ave. A steam heating system and electric motors will be installed in same. Total estimated cost, $350,000.

O., Cleveland—Joseph & Feiss Co. has awarded the contract for the construction of a warehouse, boiler room and factory addition on Haight Ave., to Stone & Webster Co., 1516 Stambaugh Bldg., Youngstown. Two 300 hp. boilers with stokers will be installed in same. Total estimated cost, $750,000.

Ill., Peoria—The Advance Rumely Co., Laporte, Ind., has awarded the contract for the construction of a 2 story, 147 x 200 ft. warehouse, to W. M. Allen Son & Co., 929-32 Jefferson Bldg. A steam heating system will be installed in same. Total estimated cost, $100,000.

Minn., Austin—The Bd. Educ. has awarded the contract for installing heating, ventilating and plumbing systems in the proposed high school, to J. P. Adamson, 1920 University Ave., St. Paul, $187,900. Noted July 1.

Kan., Ottawa—The Ottawa University has awarded the contract for the construction of a 2 story, 60 x 80 ft. central heating building, to N. B. Beeler, Ottawa.

Kan., Pittsburg—The Bd. Educ. has awarded the contract for the installation of steam heating and plumbing systems in the proposed 2 story high school, to the Salina Plumbing Co., Salina, $37,583.

Mo., Kansas City—George W. Neff, 1505 Genesee St., has awarded the contract for the construction of a 3 story, 120 x 142 ft warehouse on 5th St. and Grand Ave., to the K. C. Construction Co., 822 Commerce Bldg. Contract for installing heating system has been sub-let to the U. S. Engineering Co., Kansas City. Total estimated cost, $100,000.

Tex., Dallas—The Advance Rumely Co., Laporte, Ind., has awarded the contract for the construction of a 2 story, 100 x 200 ft. warehouse, to the Hedrick Construction Co. A steam heating system will be installed in same. Total estimated cost, $125,000.

Tex., Mineral—The Crazy Well Water Co. has awarded the contract for the construction of a 1 and 5 story, 130 x 160 ft. water bottling works, to the Industrial Bldg. Co., 38 South Dearborn St., Chicago. A steam heating system will be installed in same. Total estimated cost, $125,000.

Cal., Richgrove—The Southern California Edison Co., Edison Bldg., Los Angeles, has awarded the contract for the construction of a 3 story, 67 x 130 ft. sub-station, to Macdonald & Driver, 608 Hibernian Bldg., Los Angeles. Estimated cost, $111,000.

Cal., San Jose—The Security Warehouse & Distributing Co. has awarded the contract for the construction of a warehouse and cold storage buildings to F. L. Hoyt, 566 North 16th St. Total estimated cost, $500,000.

Ont., Toronto—The Willard Chocolates, Ltd., 443 Wellington St., W., has awarded the contract for the construction of a 5 story, 80 x 150 ft. chocolate factory on Dupont St. and Manning Ave., to Wells & Gray, Confederation Life Bldg. A vacuum steam heating system will be installed in same. Total estimated cost, $150,000.

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